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Bulletin



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Volume 28
1961-1963

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Page 236, column 1, lines 26 and 35 of text matter; page 287, column 2, line 34 of index; page 297, column 2, line 12 of index. For *annectans* substitute *annectens*.

Contents page at bottom, Volume 28, Article 3. Dr. Graber should have been identified as Associate Wildlife Specialist instead of Wildlife Associate.

Because each article of Volume 28 has been indexed separately, an index for the entire volume has not been made.

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The Amphibians and
Reptiles of Illinois

PHILIP W. SMITH

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PHILIP W. SMITH
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This paper is a contribution from the Section of Faunistic Surveys and Insect Identification.

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FOREWORD

FOR THE BETTER PART of a century the *Bulletin* has published research reports on the ecology, biology, and taxonomy of the flora and fauna of Illinois. The present number is a worthy continuance of these scientific contributions. It was prepared under those legal charges to the Board of Natural Resources and Conservation, the agency which controls, guides, and governs the activities of the Natural History Survey, to "conduct a natural history survey of the State giving preference to subjects of educational and economic importance," and "To publish, from time to time, reports covering the entire field of zoology and botany of the State."

It is probable that no other groups of animals have such staunch friends and adamant adversaries as do the amphibians and the reptiles, the subjects of this contribution. They are important to us in many ways, and, if they were not, "the characteristically human desire to investigate the unknown . . . provides an incentive to study them," as the author of this paper states.

We humans are likely to be selfish in our dealings with the so-called lower animals and to measure the worth of these animals only in terms of their economic effect upon us. We find that many amphibians and reptiles add materially to the well-being of people—some by the destruction of harmful insects and rodents, others by affording additions to our diet, as with frog legs or (to the adventurous palate) rattlesnake flesh.

Those people with an aesthetic bent find in amphibians and reptiles a great deal of grace and beauty. Those interested in curious things find their inquisitiveness satisfied among animals which have no legs, or which can change color, or which breathe largely through their skins, or which go through generation after generation without really growing up. Those who look for antiquity find that giant amphibians and reptiles developed, prospered, and passed on as living entities long before Nature

began to experiment with the upright bipedal animals we call humans.

Amphibians and reptiles are excellent organisms to study if one is interested in the variability of living things, as Dr. Philip W. Smith has amply demonstrated in this article.

The movement of animals over the face of the earth in times past has intrigued biologists since the time of Aristotle. How did the present Illinois amphibians and reptiles reach the state? If they came from outside its limits, from what direction did they emigrate? What were the reasons for this movement? Illinois has proved to be a meeting place for many forms which apparently came from all directions, and many were unable to get past it or to invade it completely. Of the 94 species discussed here, only 25 are state-wide in their distribution. The other 69 have met limiting barriers somewhere in Illinois. For many species, parts of the state represent uninhabited islands, with the populations lapping at the shorelines on two, three, or four sides, but unable to overflow the highlands. For other species, parts of the state seem to represent pools, small pockets of animals which cannot get out of circumscribed areas.

The study on which the present report is based was initiated in June, 1947, and was one of the principal research projects of the Section of Faunistic Surveys and Insect Identification until June, 1953. The manuscript was completed in May, 1957, and was submitted for publication at that time. Budgetary reasons necessitated setting it aside until July, 1959. Although some revision has been necessary to bring the nomenclature and certain concepts up-to-date, the manuscript is approximately the same as that submitted in May, 1957, and only the most pertinent of the recent literature has been incorporated.

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Clifford H. Pope
1899—

Fred R. Cagle
1915—



Important contributors to the knowledge of the Illinois herpetofauna.

The Amphibians and Reptiles of Illinois

PHILIP W. SMITH

THE AMPHIBIANS AND REPTILES comprise two classes of vertebrate animals. The class Amphibia includes three present-day orders, the Caudata (salamanders), Salientia (frogs and toads), and the Gymnophiona (caecilians). The class Reptilia includes four present-day orders, the Testudines (turtles), Squamata (lizards and snakes), Crocodylia (crocodilians), and Rhynchocephalia (*Sphenodon*). In the fauna of Illinois, amphibians are represented by salamanders, toads, and frogs; reptiles by turtles, lizards, and snakes. Altogether 109 different kinds of these animals have been found in the state.

In our natural economy the amphibians and reptiles, because of their predation on insects and destructive rodents, are on the side of man. Their exact role in the so-called balance of nature is at this time poorly known, but their existence is probably of some importance to other organisms in the over-all fauna. To many people amphibians and reptiles are fascinating and colorful creatures, and the characteristically human desire to investigate the unknown and to accumulate knowledge provides an incentive to study them. The increase in popularity in recent years of these animals is reflected by the number of people who now have pet turtles, lizards, and snakes.

Four of our Illinois snakes are poisonous. Although these snakes are uncommon in most parts of the state, a few persons are bitten by them, and many persons worry needlessly because harmless species are mistaken for poisonous species. It is advisable for everyone who spends much time out-of-doors to learn to distinguish the poisonous species; this can be done readily with the information in this bulletin.

A detailed study of the present-day Illinois amphibians and reptiles is bringing to light important data that help the scientist to look back into the past history of the earth and its life. Illinois has contributed especially significant data to biogeography, particularly in helping to disclose the movements of animals in and around Illinois dur-

ing the advance and retreat of the glaciers of the Pleistocene.

The objectives of this report on the amphibians and reptiles of Illinois are threefold. The first is to provide a critical review of the species and subspecies known to inhabit Illinois. The second is to present detailed distributional information for these animals in the hope that the data may contribute to the knowledge of the ecology and biogeography of Illinois. The third is to call attention to variation trends that I have discerned within Illinois and that will enable future investigators to utilize character analyses for populations occurring in limited parts of the state.

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The co-operation of several institutions and a great many persons has materially increased our knowledge of the herpetofauna of Illinois. The institutional and private collections that have made their holdings available to me are as follows: Chicago Academy of Sciences, Chicago, Illinois (CAS); Carthage College, Carthage, Illinois (CC); Chicago Natural History Museum, Chicago, Illinois (CNHM); collection of Charles W. Myers, St. Louis, Missouri (CM); Cornell University, Ithaca, New York (CU); Eastern Illinois University, Charleston, Illinois (EIU); collection of Fred A. Shannon, Wickenburg, Arizona (FAS); field zoology collection accumulated at the University of Illinois by the late H. J. Van Cleave, Urbana, Illinois (HJVC); Illinois Natural History Survey, Urbana, Illinois (INHS); Illinois State Museum, Springfield, Illinois (ISM); collection of James C. List, Paducah, Kentucky (JCL); Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Nebraska State Museum, Lincoln, Nebraska (NSM); Principia College, Elsah, Illinois (PC); collection of Richard A. Edgren, Chicago, Illinois (RAE); collection of Robert C. Schroder, Rock Island, Illinois (RCS); Rockford

Museum of Natural History, Rockford, Illinois (RMNH); collection of Sherman A. Minton, Indianapolis, Indiana (SAM); Southern Illinois University, Carbondale, Illinois (SIU); University of Illinois Museum of Natural History, Urbana, Illinois (UIMNH); University of Michigan Museum of Zoology, Ann Arbor, Michigan (UMMZ); University of Rochester, Rochester, New York (UR); United States National Museum, Washington, D. C. (USNM).

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PREVIOUS HERPETOLOGICAL INVESTIGATIONS

Three reports on the amphibians and reptiles of Illinois have appeared. One of these is a briefly annotated check list, one a key only, and one an excellent account, which is, however, more than 60 years old. Four papers dealing with limited groups of the herpetofauna and approximately half a dozen papers treating the species of limited re-

gions within Illinois have been published. The great majority of the references to Illinois in the literature are incidental, either citing specimens collected at localities in Illinois or merely stating that Illinois is within the range of the species.

The earliest specific reference to an amphibian or reptile in Illinois appears to be an observation by Thomas Say (1823) in the account of Long's expedition to the Rockies, just 5 years after Illinois became a state. Say records in his narrative that he observed a female of the then recently described *Graptemys geographica* laying eggs on the bank of the Ohio River near Shawneetown. Fifteen years later Holbrook (1838) described *Emydoidea blandingi* from the Fox River of northern Illinois. Gebhard (1854) recorded the first amphibian for the state by citing a specimen of *Hemidactylum* [sic] from Illinois. Kennicott (1855) prepared the first regional list with his catalog of Cook County quadrupeds. His list records 12 amphibians and 21 reptiles still recognized as part of the Cook County fauna. Later Kennicott (1856) described *Natrix kirtlandi* from West Northfield, and (1859) *Virginia valeriae elegans* from "southern Illinois," and *Ophibolus evansii* from "central Illinois." During the next 25 years such authors as Cope, Cooper, Yarrow, Jordan, and Kennicott published papers containing incidental references to the herpetofauna of Illinois.

Davis & Rice (1883a) published the first state list; their check list correctly recorded 29 species of amphibians and 54 reptiles, as well as a number of other species whose occurrence is now known to be quite impossible in Illinois. In the same decade Schneck (1880-1886), a physician and naturalist in Mount Carmel, was active in the Wabash River valley, and his several short notes in the *American Naturalist* recorded a number of reptiles in southeastern Illinois. Cope (1888) described *Lampropeltis triangulum sypila* from Richland County and (1889) *Hyla phaeocrypta* from Mount Carmel. Harrison Garman (1889, 1890) recorded the animals occurring in the Mississippi River bottoms near Quincy and reported several species for the first time from the state. Hay (1881-1892), studying the herpetology of Indiana, contributed to the knowledge of the Illinois herpetofauna by citing Illinois localities for several species.

Cope (1892) described *Thamnophis sirtalis semifasciata* from Des Plaines in northeastern Illinois.

The synopsis by Harrison Garman (1892), until now the only comprehensive report on the Illinois amphibians and reptiles, credited correctly 31 species of amphibians and 58 reptiles to Illinois, but unfortunately perpetuated most of the errors of Davis & Rice. Hurter (1893-1911) added several species to the known fauna of southwestern Illinois and, in his *Herpetology of Missouri*, described *Chrysemys treleasei* from Madison, St. Clair, and Monroe counties, Illinois.

In the early part of the present century, Robert Ridgway was responsible for a great quantity of Illinois material which found its way into the United States National Museum. Ridgway was also responsible for a number of erroneous records, presumably based on his recollections of species probably misidentified in the field. Shelford (1913) cited a number of species for northeastern Illinois in his *Animal Communities of Temperate America*. Gaige (1914) recorded 16 species of amphibians and reptiles for Richland County, and Hankinson (1910-1917) reported the common species of Coles County. Weed (1922, 1923) studied the amphibians and reptiles of the Meredosia area, and Blanchard (1924b) reported several new records for Monroe and Randolph counties. Van Cleave (1928) prepared tabular keys for the identification of the snakes of Illinois.

About 1930 K. P. Schmidt stimulated an interest in the amphibians and reptiles of the Chicago region, and his popular accounts of the amphibians (1929, 1930) were followed by a number of papers by Walter L. Necker and others. Schmidt & Necker (1935) published a useful report on the Chicago area species and cited specific localities for all the known amphibians and reptiles listed. W. F. Stanley, working for the Illinois Natural History Survey, accumulated a considerable number of Illinois snakes through co-operation of the Civilian Conservation Corps. Burt (1928-1931) cited Illinois specimens in several brief papers on the herpetofauna of the Midwest. Goodnight (1937) prepared a key to the salamanders of Illinois, and Cahn (1937) published his excellent monograph of the turtles of the state.

About 1940 Cagle began publishing the results of his studies on the fauna of southern Illinois and in 1941 he published an illustrated key to the amphibians and reptiles known for the entire state. This much-needed key was the third paper to treat all amphibian and reptile groups of Illinois. Thirty species of amphibians and 67 of reptiles were recorded as occurring in the state. Owens (1941) reported the common species in Macoupin County, and Lueth (1941) wrote a popular manual of the snakes of Illinois. Peters (1942) listed the species known to occur in Cumberland County, and Cagle (1942a) published a detailed account of the herpetofauna of Union and Jackson counties. Pope (1944b) summarized the distributional information of the several papers on the amphibians and reptiles of the Chicago area in his extremely useful handbook on the species occurring in northeastern Illinois. Langebartel (1947) reported the snakes known to occur in Hancock County and added *Carphophis amoenus vermis* to the known fauna of the state. P. W. Smith (1947) analyzed the herpetofauna of east-central Illinois and recorded 50 species and subspecies for that part of the state. Edgren & Stille (1948) published several papers on the species inhabiting the Chicago region and they added numerous distributional records for northeastern Illinois. Minton & Minton (1948) cited a number of specimens from southern Illinois, and Grimmer & Langebartel (1948) reported *Eurycea longicauda melanopleura* as a state record for Illinois. P. W. Smith (1948) added *Plethodon dorsalis* and *Gastrophryne carolinensis* to the known amphibian fauna and confirmed the suspected occurrence of *Desmognathus fuscus* and *Scaphiopus holbrookii* in Illinois.

Smith & Burger (1950) reported the first Illinois specimens of *Masticophis flagellum*, *Elaphe guttata*, and *Tantilla gracilis*, and P. W. Smith (1951) described and named *Pseudacris streckeri illinoensis* and *Kinosternon flavescens spooneri* from western Illinois sand prairies. Bennett (1953) added *Cemophora dolia* to the known snake fauna. P. W. Smith (1953-1957) summarized the known distribution in Illinois of *Tropidoclonion lineatum* and *Hyla avivoca*; resurrected the name *semifasciata* for the population of garter snakes occurring in northeastern Illinois; called attention to a

south-north clinal reduction in number of body blotches in snakes, a reduction that presumably is a manifestation of Gloger's Rule; and offered a reconstruction of the post-Wisconsin biogeography of Illinois and neighboring states. Smith & Minton (1957) summarized distributional data for Indiana and Illinois and discussed postglacial dispersal patterns of amphibians and reptiles.

ILLINOIS AS A HERPETOFAUNAL REGION

The natural areas of Illinois have had a great amount of human alteration within historic times. Many natural habitats have been transformed into cities or cornfields, others greatly reduced in extent, and still others variously modified from their original condition. In a sense, all of the habitats are relictual, separated from each other by expanses of cultivated fields. The state could be described as a great corn desert containing remnants of many habitat types.

Although herpetological collecting is relatively poor in most parts of the state, Illinois has an unusually large number of recorded species and subspecies. The richness of its fauna, from the standpoint of numbers of species, is due to its great length from north to south, its ecologically intermediate position, its biogeographical history, and its variety of habitat types.

Physical Features

Illinois, fig. 1, has a maximum length of approximately 385 miles from north to south and a maximum width of 215 miles from east to west. The state, which contains 56,400 square miles, is moderately well drained by rivers flowing into the Mississippi on the west, the Ohio on the south, and the Wabash on the east. The greater part of the state is a flat or rolling plain. The elevation, which averages about 600 feet for the entire state, decreases from north to south. The lowest part of Illinois is in Alexander County, at the southern tip, approximately 300 feet above sea level. The Shawnee Hills, which extend across the state near the southern tip, the unglaciated area in extreme northwestern Illinois, and a narrow belt of rock bluff and dissected hills along the Mississippi River have moderate relief; the first two areas have elevations slightly over 1,000 feet.

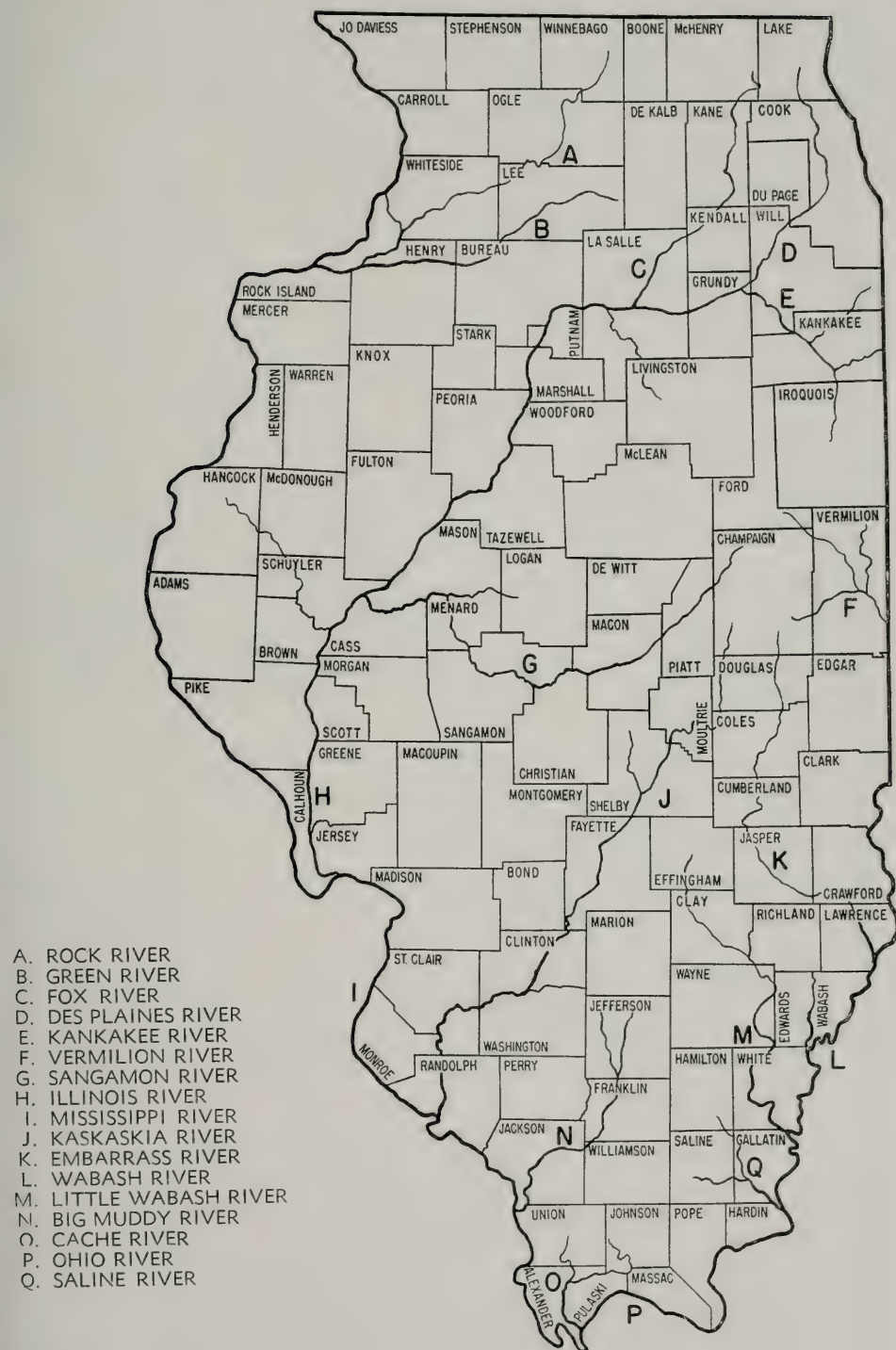


Fig. 1.—Map of Illinois showing counties and major rivers.

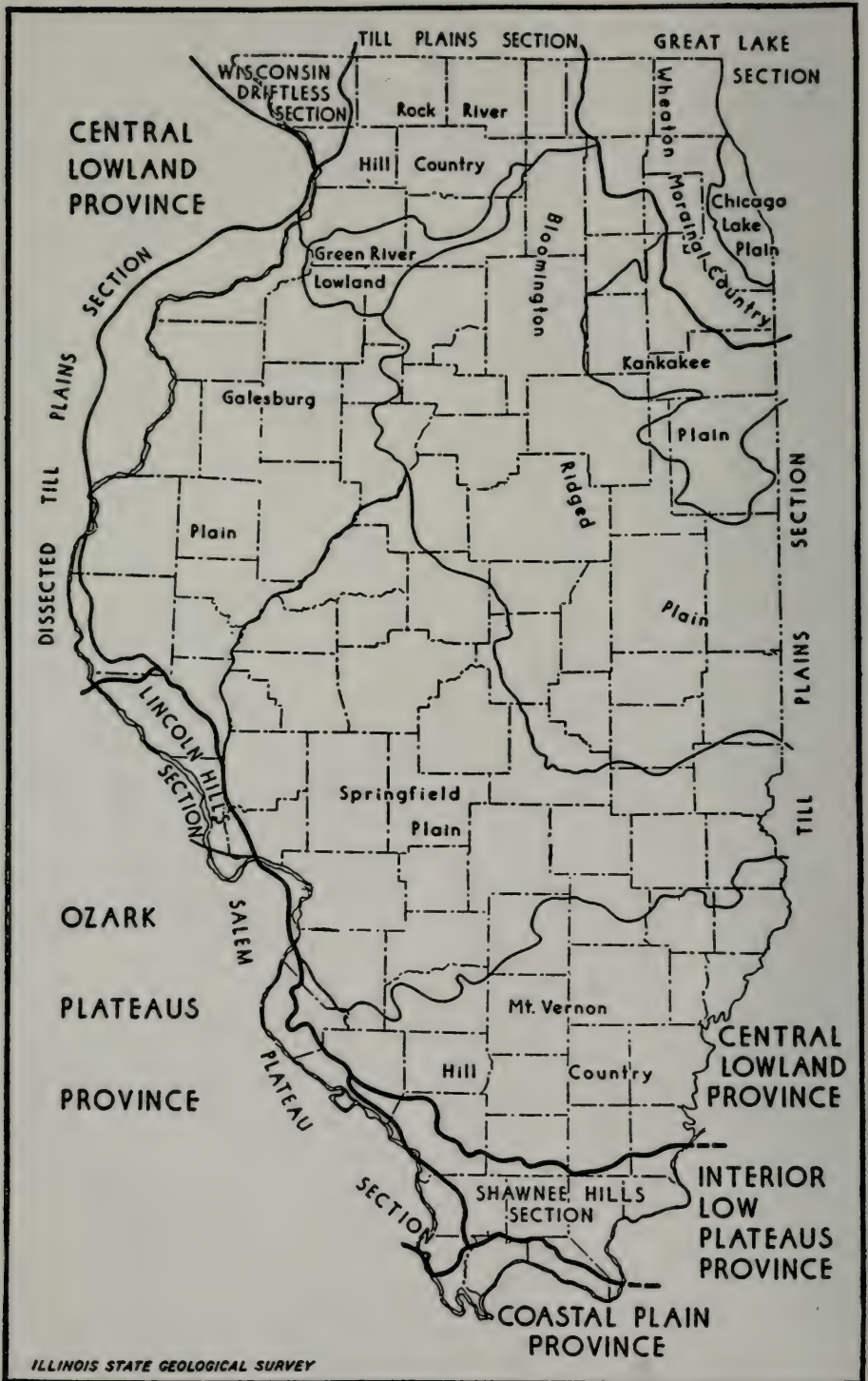


Fig. 2.—Physiographic divisions of Illinois. From Leighton, Ekblaw, & Horberg (1948).

The present topography reflects the Pleistocene history of the area. Although four stages of glacial advance, separated by interglacial periods of milder climate, are known to have occurred, the Illinoian lobe (over

100,000 years ago) and the Wisconsin lobe (about 20,000 years ago) are largely responsible for the physiography of Illinois. Much of the northern half of the state is covered with thick deposits of relatively re-

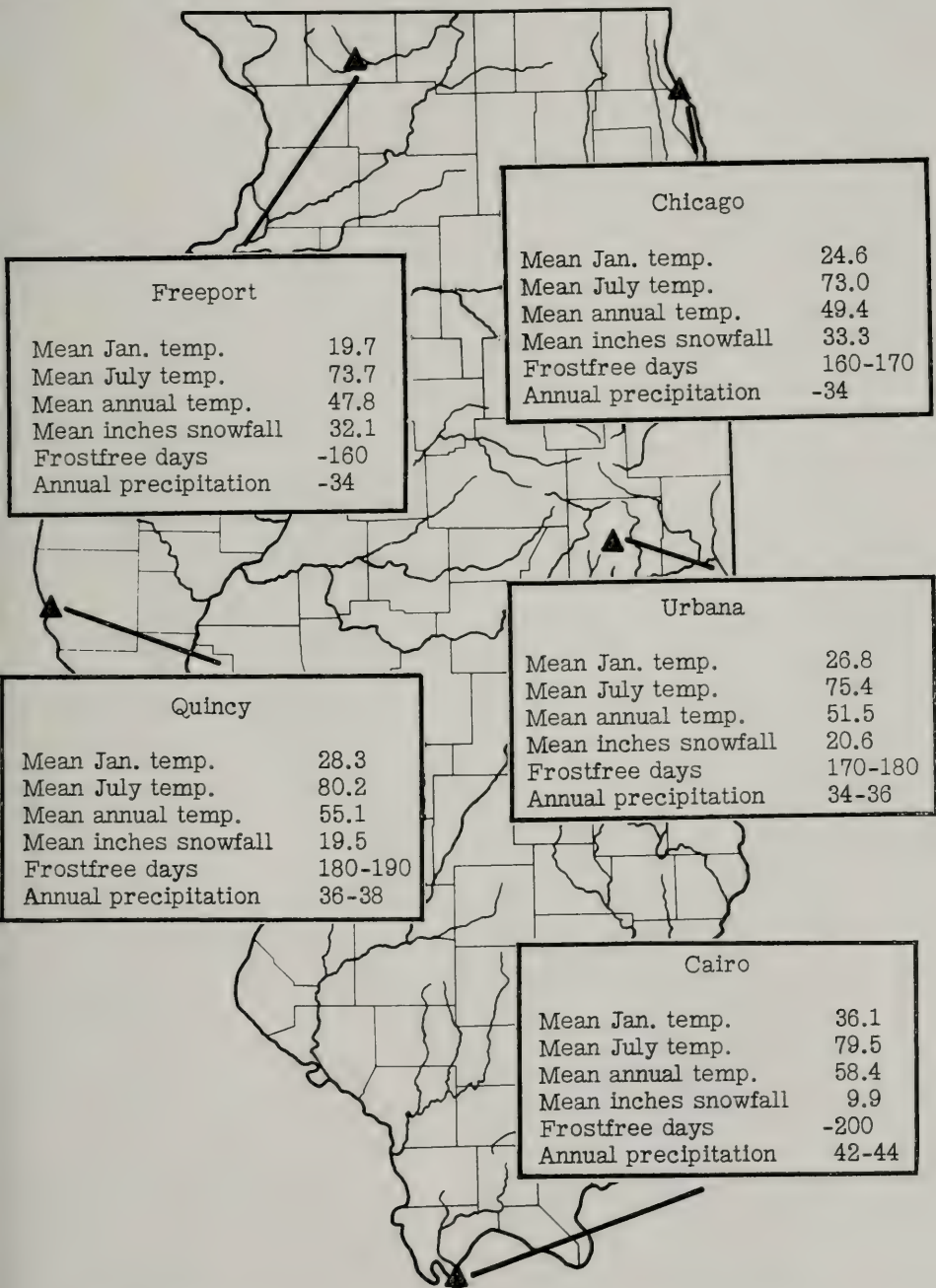


Fig. 3.—Temperature and precipitation data for five Illinois cities. Data from Page (1949).

cent Wisconsin till. Superimposed on this in gradually increasing depths to the west are deposits of fertile loess. The flat or rolling plains are marked by series of low concentrically arranged recessional moraines, the southernmost of which is the Shelbyville terminal moraine.

The glaciated area south of the Shelbyville moraine has deposits of older, less fertile Illinoian till, and moraines are no longer evident. This region has slightly more relief than the area north of the Shelbyville moraine, since the processes of erosion have had a longer time to cut valleys.

Rock outcrops are prominent features in the landscape in the Shawnee Hills, in the northwestern unglaciated area, and along the large rivers. Rock strata appear above the glacial till in small areas throughout the state, particularly in extreme eastern and western Illinois.

The physiographic divisions of Illinois have been described by Leighton *et al.* (1948). These divisions are shown in fig. 2.

Climatic Features

Illinois has a continental climate. The isotherms are in general from east to west and indicate an increase in temperature from north to south. The difference in average temperatures between northern and southern Illinois is much less marked in summer than in winter. The isohyets are somewhat less regular than the isotherms; in general, the annual precipitation increases from north to south. Union County receives a greater amount of rainfall than any other county.

The influence of latitude on temperature and the geographic variation in precipitation are illustrated by statistics taken over a period of several years at scattered Illinois localities, fig. 3.

Biotic Provinces

According to the Merriam (1894) classification, Illinois contains three life zones. Extreme northern Illinois is regarded as Transition, extreme southern Illinois as Austroriparian, and the area in between as Carolinian. According to the Shantz & Zon (1924) classification, Illinois includes four vegetation types. Extreme northeastern Illinois is classed as Marsh Grass, most of northern and central Illinois as Tall Grass Prairie, southern Illinois, except for the

lowermost tip, as Oak-Hickory Forest, and extreme southern Illinois as River Bottom Forest (cypress-tupelo-red gum). According to Dice (1943), the state has three biotic provinces. The northern half is regarded as Illinoian; the southern half, except for the southern tip, as Carolinian; and extreme southern Illinois as Austroriparian. Ken-deigh (1951) indicates the presence of two biomes in Illinois. The northern half is predominantly Grassland Biome, the southern half Temperate Deciduous Forest Biome. The forest is subdivided into three associations, the largest of which is an ecotone between oak-hickory forest and humid prairie. The animal communities are regarded as a Deciduous Forest Biociation, a Deciduous Forest-Edge Biociation, and a Prairie Biociation.

All of these classifications are based on the vegetation or biota of the entire continent, and the boundaries are necessarily inexact in any minute geographical area. It is noteworthy that all of them indicate that the southern tip of this state is ecologically distinct, and most of them indicate in central Illinois an ecological break that roughly coincides with the southern limit of Wisconsin glaciation.

A detailed classification of zones in Illinois is expressed by Vestal (1931), who based his divisions upon forest types. In many parts of the state, the distribution of the herpetofauna parallels remarkably the distribution of these types. Vestal's map of Illinois has the following eight divisions: Grand Prairie, Western Division, Jo Daviess Hills, Mississippi Border, Southern Division, Wabash Border, Ozark Hills, and Tertiary Division, as shown in fig. 4.

Herpetofaunal Divisions

Although the herpetofaunal distribution tends to coincide with the vegetational divisions of Vestal (1931), certain differences exist that should be recognized. The distinctive herpetofaunal divisions are outlined below and shown in fig. 5.

I. Prairie or former prairie

- A. Sand areas
- B. Grand Prairie (broad sense)
- C. Outlier prairies

II. Forest

- A. Northeastern Illinois Mesic Forest
- B. Western Division

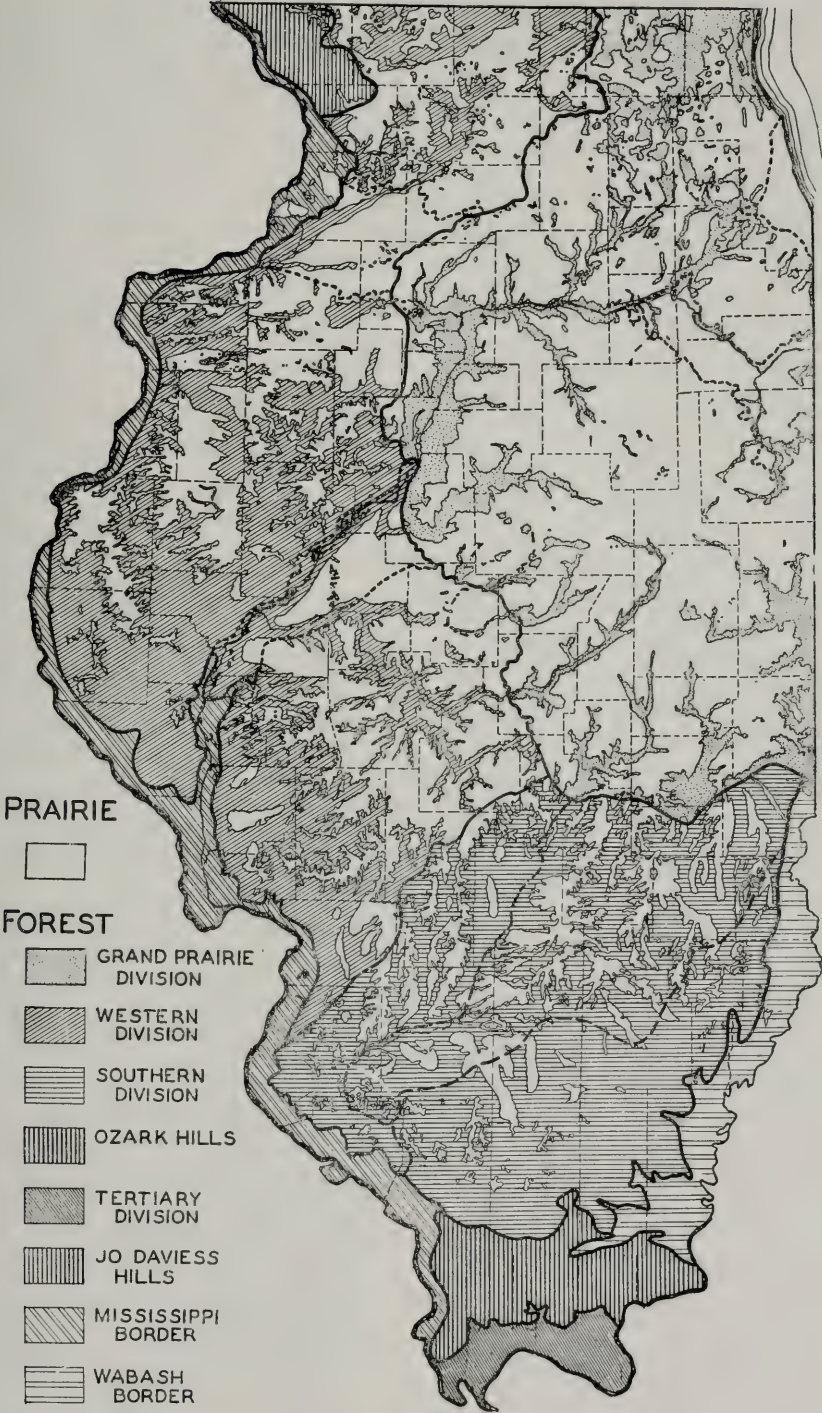


Fig. 4.—Vegetation map of Illinois, based on original cover. From Vestal (1931). Forest occupies a relatively small per cent of Illinois at present.



Fig. 5.—Herpetofaunal divisions of Illinois. The similarity of herpetofaunal, vegetation and physiographic divisions is notable. Coincidence of boundaries is most pronounced at the southern limits of Pleistocene glaciation and the northern border of the Coastal Plain.

- C. Upper Mississippi Border
- D. Lower Mississippi Border
- E. Southern Division
- F. Wabash Border
- G. Shawnee Hills
- H. Austroriparian

Ninety-four species of amphibians and reptiles occur in Illinois; 25 are state-wide in distribution and 69 occupy limited parts of the state. The edges of ranges of these 69 have been plotted on one map, fig. 6. It is evident from this map that the ranges of the various species are not uniformly shingled over the state but that the range edges of many tend to coincide. Some areas are relatively uniform ecologically and have few species reaching the edges of their ranges therein. Fig. 6 demonstrates the variability of fig. 5.

The Sand Areas.—The areas of sand prairie, which are relatively small, are

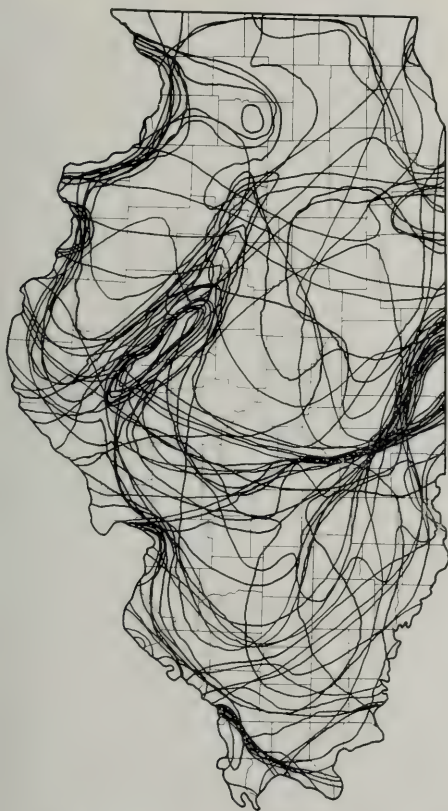


Fig. 6.—Limits of distribution of the amphibians and reptiles of Illinois. Each line represents the edge of range of a species. In some areas, lines coincide.

chiefly in central and northern Illinois. The largest area extends along the east side of the Illinois River from Woodford County south to northern Scott County. Smaller sand areas occur in Jo Daviess, Carroll, Rock Island, Whiteside, Mercer, and Henderson counties, along the east side of the Mississippi River; in Ogle and Lee counties; in Winnebago County; in Kankakee and Iroquois counties. Small areas of sandy loam occur in Lawrence, La Salle, and Lake counties. A typical sand prairie habitat is shown in fig. 7.

The most abundant reptiles of the sand areas are *Cnemidophorus sexlineatus*, *Pituophis melanoleucus sayi*, *Coluber constrictor flaviventris*, *Heterodon platyrhinos*, *Heterodon nasicus*, *Terrapene ornata*, and *Trionyx muticus*. The distinctive species of amphibians and reptiles are *Pseudacris streckeri illinoensis*, *Kinosternon flavescens spooneri*, and some of the reptiles mentioned as abundant are also characteristic. A depauperate salamander fauna and the local predominance of *Bufo woodhousei fowleri* over *Bufo americanus americanus* are also characteristic of this division.

The Grand Prairie.—This division as here defined comprises all original prairie, except the sand areas, north of the southern limit of Wisconsin glaciation. It includes accordingly the Grand Prairie (in the strict sense), the Mendota Prairie, and most of the prairies included in Vestal's Western Division. Much of this area has fertile soil, consisting of Wisconsin glacial till and loess, and is now extensively cultivated. It has been characterized by various authors as muck prairie, black-soil prairie, and heavy-soil prairie. The eastern part of the area was formerly dotted with marshes and ponds, most of which have been drained.

The most abundant species of amphibians and reptiles are *Bufo americanus americanus*, *Thamnophis radix*, *Elaphe vulpina*, *Pituophis melanoleucus sayi*; probably *Sistrurus catenatus* and *Emydoidea blandingi* were once abundant. The distinctive species are *Natrix kirtlandi*, *Tropidoclonion lineatum*, *Opheodrys vernalis*, as well as some of the above species indicated as abundant. Although none of these is entirely restricted to the Grand Prairie, each reaches its greatest abundance in the region.

The Outlier Prairies.—These fingers of prairie, which interdigitate with forest in the



Fig. 7.—A typical sand prairie habitat near Thomson, Whiteside County, Illinois.

southern half of Illinois, were included by Vestal in the Southern Division. The northern edges of this division are not sharply delimited from the Grand Prairie, and the Springfield District of Vestal is, in fact, ecotonal in herpetofaunal composition. The soil is rather poor, consisting of clay loam with hardpan a foot or two below the surface.

The abundant species are *Ambystoma texanum*, *Bufo woodhousei fowleri*, *Coluber constrictor*, *Lampropeltis calligaster*, and *Heterodon platyrhinos*. The distinctive species are *Rana areolata* and *Terrapene ornata*. A few relict colonies of *Ophedrys vernalis*, *Thamnophis radix*, *Sistrurus cernatus*, and *Natrix grahami* link this division with the Grand Prairie. The erratic occurrence of some of these scattered colonies is difficult to explain. It seems unlikely that cultivation is solely responsible.

Northeastern Illinois Mesic Forest.—The forested moraines and bogs near Lake Michigan contain a relatively rich fauna and are distinctive chiefly because of the occurrence of northern and eastern elements. The abundant species are *Ambystoma maculatum*, *Rana sylvatica*, *Lampropeltis triangulum triangulum*, *Storeria occipitomaculata*, and *Natrix septemvittata*. The distinctive species are *Ambystoma laterale*, *Hemidactylium scutatum*, *Clemmys guttata*, and *Thamnophis sirtalis semifasciata*.

The Western Division.—The small patches of woodland and gallery forest along rivers and creeks of this division are rather remarkable for their impoverished fauna. Although apparently suitable habitat for many forest species is available, most of the species known in adjacent divisions have not been found in these forested areas. *Acris crepitans*, *Pseudacris triseriata triseriata*, *Rana pipiens pipiens*, *Rana clamitans*, *Thamnophis sirtalis*, and *Lampropeltis triangulum* are moderately common; all are more abundant in other parts of Illinois.

The Upper Mississippi Border.—This division, which includes the forested bluffs of the Mississippi River and the Jo Daviess County driftless area, is much richer in number of species than the Western Division. The extensive rock habitat and the continuity of forest along the Mississippi, which serves as an avenue for the northward dispersal of southern animals, probably accounts for the large number of species in this area.

The common species are *Natrix sipedon*, *Diadophis punctatus*, *Elaphe obsoleta*, *Thamnophis sirtalis*, and *Rana clamitans*. The distinctive species are *Eurycea longicauda melanopleura*, *Carphophis amoenus vermis*, *Diadophis punctatus arnyi*, and *Rana palustris*.

The Lower Mississippi Border.—The bluffs and dissected upland along the Mississippi River south of St. Louis have a spe-

cies composition and an order of relative abundance similar to that of the Upper Mississippi Border. This division has more affinities with the Shawnee Hills, however, and has, in addition, several western and southern elements not found elsewhere in the state. The distinctive species are *Tantrilla gracilis*, *Masticophis flagellum*, *Elaphe guttata emoryi*, and *Gastrophryne carolinensis*.

The Shawnee Hills.—This division is characterized by forested, dissected upland with sheer bluffs and rock outcrops. The streams, usually fast and clear, have rocky bottoms. The area is rich in numbers of species and individuals. The abundant species are *Ambystoma opacum*, *Plethodon glutinosus*, *Eurycea longicauda*, *Eurycea lucifuga*, *Hyla crucifer*, *Hyla versicolor*, *Sceloporus undulatus*, *Scincella laterale*, *Eumeces* spp., *Agkistrodon contortrix*, *Elaphe obsoleta*, *Coluber constrictor*, *Thamnophis sauritus*, *Virginia valeriae*, and *Terrapene carolina*.

The Southern Division.—The forest of this part of Illinois is largely restricted to river bottoms and land generally unsuited for farming. The habitat is similar to that in the Shawnee Hills but has less relief and few rock outcrops and rocky streams.

The unintentional creation of parklike savannas by removal of forest provides ideal habitat for forest-edge species. The thickets, brambles, and grass (*Andropogon*) glades characteristic of this habitat are inhabited by *Bufo woodhousei fowleri*, *Ambystoma texanum*, *Heterodon platyrhinos*, *Coluber constrictor*, *Opheodrys aestivus*, *Storeria dekayi*, and *Natrix sipedon pleuralis*. The interior of the woodlands contain *Eumeces* spp., *Elaphe obsoleta*, *Lampropeltis triangulum sispila*, and *Hyla versicolor*.

The Wabash Border.—The area along the Wabash River in southeastern Illinois is similar to the Southern Division, differing primarily in the higher percentage of forested land and the mesic condition of this forest. Characteristic species are *Hyla cru-*



Fig. 8.—A typical austroriparian habitat at Horseshoe Lake, Alexander County, Illinois.

cifer, *Pseudacris triseriata feriarum* $\times$ *triseriata*, *Eumeces fasciatus*, and *Terrapene carolina*. Additional characteristic species are *Rana sylvatica*, *Natrix septemvittata*, *Natrix erythrogaster neglecta*, *Eurycea bislineata*, *Plethodon cinereus*, and *Elaphe obsoleta obsoleta* $\times$ *spiloides*.

The Austroriparian Division.—This area is the Tertiary Division of Vestal (1931), the River-Bottom Forest of Shantz & Zon (1924), and the Austroriparian of earlier authors. It includes the floodplains, fig. 8, of the Mississippi and Ohio rivers in Alexander, Pulaski, Massac, Pope, western Union, and southwestern Jackson counties. A number of species characteristic of the Gulf Coast extend up the Mississippi River valley into this division. Some of these species are *Ambystoma talpoideum*, *Hyla cinerea*, *Hyla avivoca*, *Scaphiopus holbrookii*, *Farancia abacura*, *Natrix cyclopion*, *Natrix sipedon confluens*, *Cemophora doliata*, *Agkistrodon piscivorus*, *Pseudemys floridana*, and *Macroclmys temminckii*.

PRESENTATION OF DATA

The bulk of the data for this report was accumulated during the years 1947–1953. Field work was conducted in almost all parts of the state and was particularly intensive in the peripheral areas. Records for the approximately 8,000 specimens in the Illinois Natural History Survey collection were supplemented by Illinois records from the major museums of this country, several state institutions, and a few private collections.

Complete synonymies for all Illinois species and subspecies have been compiled, but, because of their bulkiness, they have been replaced by skeleton synonymies; the synonymy for each species or subspecies consists of a chronological outline of all names and name combinations that have been applied to the taxon in the Illinois literature. Only the initial usage of a name or name combination is cited. The remaining bibliographic references and lists of published records from the time of the original description through the appearance of the sixth edition of the official check list (Schmidt 1953) are on file at the Illinois Natural History Survey offices, where they are available to anyone interested in the historical aspects of the Illinois herpetofauna.

The initial citation in every case is to the original description, whether or not Illinois is mentioned; the specific or subspecific name is followed by the name of the describer (with no comma separating them), the year the description was published, the pagination of the description, and, in parentheses, the type locality. A citation other than the original description refers to the first usage of the name in literature pertaining to Illinois; a comma follows the specific or subspecific name, and the reference is abbreviated to author, year, and pagination. The complete reference for each citation is given in the "Literature Cited" section of this paper.

If a citation refers to two different entities as now understood, the name appears in the synonymies of both forms involved and is followed by "part" in parentheses. When the citation refers to specimens or populations of intergrades between two subspecies, the name ordinarily is included in the synonymies of both forms and is followed by "I" in parentheses. The various names and name combinations have been carefully evaluated, and most of them have been definitely allocated by judicious use of our present knowledge of distribution. In a few cases some doubt about assignment of the name remains; in each of these cases the name is prefaced by a question mark. In several instances questionable records in the literature have been clarified by examination of the museum specimens on which the records were based.

The diagnosis for each species is brief and includes only those characters or combinations of characters serving to distinguish an animal from related or similar animals. In most instances it is designed merely to supplement the keys. Exceptions are made, however, for those populations which depart in structure, pattern, or color from published descriptions of the species or subspecies.

The section on variation in each species or subspecies includes a discussion of sexual dimorphism, ontogenetic variation, and geographic variation within Illinois. In an animal that occurs in a limited part of the state, individual variation is summarized. It has been assumed, in accordance with present species concepts, that each individual population probably differs to some extent from all others. Extremes and means of

counts and measurements rather than more detailed statistics are given, since they illustrate general trends and do not require correction factors for the small size of the samples. In most cases, the grouping of the samples analyzed has been selected with an eye to the probable natural limits of freely interbreeding populations. In some cases, however, the grouping has been dictated by the availability of specimens.

The habits section for each species or subspecies is intended only to give a brief summary of behavior, feeding habits, and life history information. Although a wealth of published information is available for some of the species, little of this information is based on Illinois animals. The information in the present paper, for the most part, pertains only to Illinois populations; geographic variation in habits as well as in morphology is to be expected.

The section on distribution of each species or subspecies in Illinois contains a general statement of the range of the animal in the state, an indication of its general abundance, apparent correlations of its range and the environmental features, and the extent of the intergrading areas of subspecies. In the interest of saving space, lists of locality records and specimens examined have been omitted. This information is on file at the Illinois Natural History Survey offices and can be transcribed for persons wishing to know precise localities and catalog numbers of specimens on which a record is based. Published records believed valid but not substantiated by museum specimens are listed alphabetically by counties and specific localities and followed by references to the literature cited.

The accompanying maps indicate graphically the known Illinois localities for the various species. Localities from which specimens have been examined are indicated by dots; localities for which there are literature records believed valid, but from which I have not seen specimens, are indicated by hollow circles. The presumed range of a species that does not occur throughout Illinois is indicated by parallel hatching and is based in part on the distribution of apparently suitable habitat. In the case of a species having two or more subspecies in Illinois, the range of each subspecies is indicated by a different pattern, and the intergrading area by an overlap of these patterns

to form a crosshatch pattern. The map of the United States that accompanies each Illinois map indicates the total known range of a species and in most cases is from Conant (1958).

SYSTEMATIC ACCOUNT

Amphibians and reptiles comprise two distinct classes of vertebrate animals. The modern species are survivors of those groups of vertebrates that first colonized land. They are intermediate between the bony fishes of an aquatic environment and the birds and mammals of a terrestrial environment. In general, the organ systems of amphibians reflect the series of profound changes necessary for the transition from water- to air-breathing, from swimming to locomotion on land, and from an environment emphasizing the need for water excretion to one requiring water conservation. The organ systems of reptiles reflect the various modifications which made their land colonization more successful than that of the amphibians.

In addition to gross differences in organ systems, there are numerous other anatomical features distinguishing the amphibians from the reptiles. These differences are treated in any standard textbook of comparative anatomy. The most obvious features distinguishing the amphibians from the reptiles are as follows:

- Skin without scales or plates; front feet with 4 or fewer toes; toes without claws; eggs with gelatinous coating; typically with an aquatic larval stage..... Class Amphibia, p. 21
- Skin with scales or plates, or both; front feet, if present, with 5 toes; some toes with claws; eggs with a tough membranous or limy covering; no larval stage..... Class Reptilia, p. 113

Check List of the Amphibians and Reptiles of Illinois

- Class Amphibia
 - Subclass Lepospondyli
 - Order Caudata
 - Family Cryptobranchidae
 - Cryptobranchus alleganiensis alleganiensis* (Daudin)
 - Family Ambystomatidae
 - Ambystoma laterale* Hallowell
 - Ambystoma maculatum* (Shaw)

Ambystoma opacum (Gravenhorst)

Ambystoma talpoideum (Holbrook)

Ambystoma texanum (Matthes)

Ambystoma tigrinum tigrinum (Green)

Family Salamandridae

Notophthalmus viridescens louisianensis Wolterstorff

Family Plethodontidae

Eurycea bislineata rivicola Mittleman

Eurycea longicauda longicauda (Green)

Eurycea longicauda melanopleura (Cope)

Eurycea lucifuga Rafinesque

Hemidactylium scutatum (Schlegel)

Plethodon cinereus cinereus (Green)

Plethodon dorsalis Cope

Plethodon glutinosus glutinosus (Green)

Desmognathus fuscus conanti Rossman

Family Proteidae

Necturus maculosus maculosus (Rafinesque)

Family Sirenidae

Siren intermedia nettingi Goin

Subclass Apsidospondyli

Order Salientia

Family Pelobatidae

Scaphiopus holbrooki (Harlan)

Family Bufonidae

Bufo americanus americanus Holbrook

Bufo americanus charlesmithi Bragg

Bufo woodhousei fowleri Hinckley

Family Hylidae

Acris crepitans blanchardi Harper

Pseudacris triseriata feriarum (Baird)

Pseudacris triseriata triseriata (Wied)

Pseudacris streckeri illinoensis Smith

Hyla avivoca avivoca Viosca

Hyla cinerea (Schneider)

Hyla crucifer crucifer Wied

Hyla versicolor versicolor Le Conte

Family Ranidae

Rana areolata circulosa Rice & Davis

Rana catesbeiana Shaw

Rana clamitans melanota (Rafinesque)

Rana palustris Le Conte

Rana pipiens pipiens Schreber

Rana pipiens sphenoccephala Cope

Rana sylvatica sylvatica Le Conte

Rana sylvatica cantabrigensis Baird

Family Microhylidae

Gastrophryne carolinensis carolinensis (Holbrook)

Class Reptilia

Subclass Anapsida

Order Testudines

Family Chelydridae

Chelydra serpentina serpentina (Linnaeus)

Macrolemys temmincki (Troost)

Family Kinosternidae

Sternotherus odoratus (Latreille)

Kinosternon flavescens spooneri Smith

Kinosternon subrubrum subrubrum (Lacépède) × *hippocrepis* Gray

Family Testudinidae

Glemmys guttata (Schneider)

Emydoidea blandingi (Holbrook)

Terrapene carolina carolina (Linnaeus)

Terrapene ornata ornata (Agassiz)

Chrysemys picta marginata Agassiz

Chrysemys picta belli (Gray)

Pseudemys scripta elegans (Wied)

Pseudemys floridana hoyi (Agassiz) × *concinna hieroglyphica* (Holbrook)

Gratemys geographica (Le Sueur)

Gratemys pseudogeographica (Gray)

- Family Trionychidae
Trionyx muticus muticus Le Sueur
Trionyx spinifer spinifer Le Sueur
- Subclass Lepidosauria
Order Squamata
Suborder Sauria
Family Iguanidae
Sceloporus undulatus hyacinthinus (Green)
Family Anguidae
Ophisaurus attenuatus attenuatus (Cope)
Family Teiidae
Cnemidophorus sexlineatus sexlineatus (Linnaeus)
Family Scincidae
Scincella laterale (Say)
Eumeces fasciatus (Linnaeus)
Eumeces laticeps (Schneider)
- Suborder Serpentes
Family Colubridae
Carphophis amoenus helenae (Kennicott)
Carphophis amoenus vermis (Kennicott)
Farancia abacura reinwardti Schlegel
Diadophis punctatus arnyi Kennicott
Diadophis punctatus edwardsi (Merrem)
Diadophis punctatus stictogenys Cope
Heterodon nasicus nasicus Baird & Girard
Heterodon platyrhinos Latreille
Opheodrys aestivus (Linnaeus)
Opheodrys vernalis blanchardi Grobman
Coluber constrictor flaviventris Say
Masticophis flagellum flagellum (Shaw)
Elaphe guttata emoryi (Baird & Girard)
Elaphe obsoleta obsoleta (Say)
Elaphe obsoleta spiloides Duméril, Bibron, & Duméril
Elaphe vulpina vulpina (Baird & Girard)
Pituophis melanoleucus sayi (Schlegel)
Lampropeltis calligaster calligaster (Harlan)
- Lampropeltis getulus holbrooki* Stejneger
Lampropeltis getulus niger (Yarrow)
Lampropeltis triangulum triangulum (Lacépède)
Lampropeltis triangulum sypila (Cope)
Cemophora doliata (Linnaeus)
Thamnophis sauritus proximus (Say)
Thamnophis radix radix (Baird & Girard)
Thamnophis sirtalis sirtalis (Linnaeus)
Thamnophis sirtalis semifasciata (Cope)
Tropidoclonion lineatum lineatum (Hallowell)
Virginia valeriae elegans (Kennicott)
Storeria dekayi wrightorum Trapido
Storeria occipitomaculata occipitomaculata (Storer)
Natrix cyclopion cyclopion (Duméril & Bibron)
Natrix erythrogaster flavigaster Conant
Natrix erythrogaster neglecta Conant
Natrix grahami (Baird & Girard)
Natrix kirtlandi (Kennicott)
Natrix rhombifera rhombifera (Hallowell)
Natrix septemvittata (Say)
Natrix sipedon sipedon (Linnaeus)
Natrix sipedon pleuralis Cope
Natrix sipedon confluens Blanchard
Tantilla gracilis hallowelli Cope
- Family Crotalidae
Agkistrodon piscivorus leucostomus (Troost)
Agkistrodon contortrix mokeson (Daudin)
Sistrurus catenatus catenatus (Rafinesque)
Crotalus horridus horridus Linnaeus

The preceding check list contains 109 named species and subspecies of amphibians and reptiles known in Illinois. The numer-

Table 1.—Number of species and subspecies in the herpetofauna of Illinois and some other states.

GROUP	ILLINOIS	INDIANA (MINTON, PERSONAL COMMUNI- CATION)	KANSAS (H.M. SMITH 1956)	MINNESOTA (BRECKEN- RIDGE 1944)	GEORGIA (MARTOF 1956)
Salamanders.....	19	20	10	5	57
Frogs and toads.....	21	14	24	13	34
Turtles.....	17	15	13	8	35
Lizards.....	6	6	16	3	15
Snakes.....	46	33	46	16	59
Crocodilians.....	0	0	0	0	3
Total.....	109	88	109	45	203

ical distribution of species and subspecies in each group for Illinois and for some other states that have been recently surveyed are shown in table 1.

Species Deleted From the Illinois List

In recent years the natural range of a species of amphibian or reptile has become increasingly difficult to determine because numerous individuals have been carried by human agency into areas new to them. Many snakes, turtles, and lizards have been captured by travelers, taken from their natural ranges, kept for a while as pets, and then released or allowed to escape. More than a dozen extralimital species of amphibians and reptiles, obviously escapees, released pets, or "banana-bunch" waifs, have come to my attention in the course of this survey, and perhaps there are many more never reported to a biologist. Although reports of the alligator and boa constrictor in Illinois are rather easily dismissed, reports of other species may be troublesome to evaluate.

The evaluation of numerous museum specimens for which the locality data are suspected of being in error presents a serious problem. Some errors result from lack of accuracy in cataloging, others from carelessness in storing or labeling specimens. Many of these errors are introduced into the literature by specialists who study the specimens and cite the locality data, even though the data appear to be dubious. Errors are perpetuated by other specialists who cite the published records. On the basis of our present knowledge, the Illinois records for the following species are regarded as having been based on error, and these

species are here excluded from the list of Illinois amphibians and reptiles until additional evidence is available.

Pseudotriton ruber ruber (Latreille).—This eastern salamander has had an unusually complicated history. Yarrow (1882a) cited a specimen of *Spelerpes ruber* from Aux Plaines, Illinois. The species was credited to Illinois by Davis & Rice (1883a), Hay (1887a), and H. Garman (1892) on the authority of Yarrow.

The confusion of *P. ruber* and another red salamander, *maculicaudus* (equals *Eurycea lucifuga*) probably led to the assumption by Stejneger & Barbour (1917) that *P. ruber* occurred in Illinois. Dunn (1926) questioned the Aux Plaines record, and Schmidt & Necker (1935) deleted the species from the known fauna of the Chicago area. However, Goodnight (1937), on the authority of Yarrow, included the species in his key. The Aux Plaines locality is almost 400 miles northeast of the westernmost generally accepted record for the species, and no specimens are known from other parts of Illinois, from Indiana, or from western Kentucky. Accordingly, *P. ruber* should be dropped from the list of Illinois salamanders.

Pseudobranchius striata (Le Conte).—H. Garman (1892) remarked: "So many southern species inhabit the south part of the State that it would not be surprising if *Pseudobranchius striata* should also be found to occur there." The species has, however, never been found north of southern Georgia.

Hyla squirella Bosc.—The squirrel tree-frog was credited to Illinois by Davis & Rice (1883a), H. Garman (1892), Hart &

Gleason (1907), Cagle (1941), Brown (1950), and Schmidt (1953). The early references to the species in the state were probably based on misidentified specimens of related hylids; the later references may have been based on the assumption that *squirella* occurred in extreme southern Illinois in view of its alleged occurrence in western Kentucky. Recently, at the suggestion of Roger Conant and through the courtesy of Roger Barbour, I examined the Kentucky specimens and found them to be aberrant specimens of *Pseudacris triseriata feriarum*. The nearest valid record of *H. squirella* is approximately 300 miles south of Illinois, and the species should therefore be dropped from the list of Illinois amphibians.

Sternotherus carinatus (Gray).—This Gulf Coast species was reported as occurring in Illinois by Davis & Rice (1883a, 1883b), Jordan (1888), H. Garman (1892), and Hay (1892a), but it was correctly deleted from the list of Illinois turtles by Cahn (1937).

Terrapene carolina triunguis (Agassiz).—The evidence for deleting this subspecies is presented in the discussion of geographic variation of *T. c. carolina* on page 135.

Chrysemys picta dorsalis Agassiz.—The evidence for deleting this subspecies is presented in the discussion of geographic variation of *C. p. marginata* on page 140.

Chrysemys picta picta (Schneider).—Yarrow (1882a) recorded the eastern painted turtle from Mount Carmel, and H. Garman (1890) questioned the record. Cahn (1937) deleted the subspecies from the Illinois list.

Clemmys insculpta (Le Conte).—The belief that the wood turtle might be found in northern Illinois was expressed by Stejneger & Barbour (1933, 1939, 1943), Ditmars (1936), Cahn (1937), Logier (1939), Breckenridge (1944), and McCauley (1945). Cahn summarized the possibility that the species might occur in this state, pointing out that a record is extant from a locality only 11 miles north of the Wisconsin-Illinois state line. There is, however, some question about this record, and *C. insculpta* should be dropped from the known turtle fauna of Illinois until additional evidence is available.

Trionyx ferox ferox (Schneider).—Kennicott (1855) included this southern turtle in his Cook County list, but his specimen

undoubtedly belonged to *T. spinifer spinifer*, as Schmidt & Necker (1935) pointed out. H. Garman (1892) presumed that *ferox* might occur in the Ohio and Mississippi rivers, but Neill (1951a) showed that *ferox* is unknown north of southern Georgia.

Phrynosoma cornutum (Harlan).—Ditmars (1907) included western Illinois in the range of the Texas horned lizard, although his inclusion was presumably based on nothing more than a guess. Several specimens of this lizard have been found in Illinois, most of them in urban areas, but these are almost certainly irregulars in the fauna, inasmuch as *P. cornutum* is one of the most popular of reptile pets.

Carphophis amoenus amoenus (Say).—The references to *Carphophiops amoenus* in Illinois by Garman (1892), Cope (1900), Jordan (1929), and Ditmars (1929) were based on atypical or misidentified specimens of the subspecies *helenae*. These references antedate the present subspecies concepts; *amoenus* is now known to be replaced by *helenae* west of the Appalachians.

Abaster erythrogrammus (Holbrook).—Robert Ridgway was apparently responsible for inclusion of Illinois in the range of the rainbow snake by Jordan (1878, 1888), Cope (1877, 1895a), S. Garman (1883, 1884), Davis & Rice (1883a), and H. Garman (1892). There is no other evidence that the species occurs north of Louisiana in the Mississippi River valley.

Heterodon simus (Linnaeus).—The reports of the southern hognosed snake in Illinois by Davis & Rice (1883a), Jordan (1888), H. Garman (1892), Hart & Gleason (1907), and Van Cleave (1928) undoubtedly refer to *H. nasicus*. The species *simus* is now known to occur no closer to Illinois than coastal North Carolina.

Lampropeltis calligaster rhombomaculata (Holbrook).—The reports of the mole snake in Illinois by Davis & Rice (1883a, 1883b), H. Garman (1892), and Jordan (1888) undoubtedly refer to misidentified specimens of *L. c. calligaster*. The latter subspecies replaces *L. c. rhombomaculata* in the areas north and west of eastern Mississippi.

Lampropeltis triangulum elapsoides (Holbrook).—The Illinois references to this southern snake (Davis & Rice 1883a, 1883b; Jordan 1888; H. Garman 1892)

belong in the synonymy of *L. t. sypila*. *L. t. elapsoides* occurs no closer to Illinois than eastern Kentucky.

Coluber constrictor constrictor Linnaeus.—The evidence for deleting this subspecies is presented in the introductory remarks concerning subspecies of *Coluber constrictor* on page 196.

Elaphe guttata guttata (Linnaeus).—The corn snake was reported as occurring in "southern Illinois" or at Mount Carmel by Yarrow (1882a), Davis & Rice (1883a), Hay (1887b, 1892a), H. Garman (1892), Cope (1900), Myers (1926), Van Cleave (1928), Minton (1944), and Perkins (1949). All of these authors, however, merely presumed that the corn snake might occur in the state, or cited Yarrow (1882a) as authority for inclusion of Illinois in the range of the species. Schmidt & Necker (1935) deleted the species from the list of Chicago area reptiles. Of the generally accepted records of *E. g. guttata*, the nearest to Illinois is for specimens from Edmonson County, Kentucky. Although the existence of a population of this species in southeastern Illinois is possible, it is much more likely that early authors confused this snake with the superficially similar *Lampropeltis calligaster*.

Virginia striatula (Linnaeus).—The brown snake was credited to Illinois by Cope (1877), Davis & Rice (1883a, 1883b), H. Garman (1892), Van Cleave (1928), Cagle (1942a), and Ditmars (1945). Cagle (1941) noted that Illinois specimens were lacking, but he believed the species might occur in southwestern Illinois. Marlin Perkins of the Chicago Lincoln Park Zoo stated that he saw the species near Murphysboro, and his recollection was cited by Ditmars and Cagle. His visual record is highly questionable, however, inasmuch as *V. striatula* can be distinguished with certainty from *V. valeriae* only with the aid of a magnifying lens. Accordingly, it seems advisable to delete this species from the list of Illinois snakes.

Virginia valeriae valeriae (Baird & Girard).—Yarrow (1882a), Hay (1892a), and Cope (1900) undoubtedly misidentified specimens of *V. v. elegans* when they recorded the nominate subspecies in Illinois. *V. v. valeriae* does not occur west of southern Ohio, being replaced by the subspecies *elegans* in the Midwest.

Thamnophis elegans hammondi (Kennicott).—Wright & Wright (1952) mentioned that an old record for "*Tropidonotus hammondi*" in Illinois had been published. They listed this among the problematical records, and I have been unable to find the original paper on which the record is based. There can be no doubt that either *T. sirtalis* or *T. radix* was mistaken for *hammondi*, which is a coastal California subspecies.

Thamnophis elegans vagrans (Baird & Girard).—The Rocky Mountain garter snake was included in Illinois reports by Davis & Rice (1883a), H. Garman (1892), and Wright & Wright (1952). Undoubtedly, a specimen of *T. sirtalis* was misidentified as *T. e. vagrans*.

Thamnophis butleri (Cope).—Ditmars (1922) noted that Butler's garter snake occurred in eastern Illinois. Davis (1932), having examined the large series of *Thamnophis* in the Chicago museums, pointed out that there were no Illinois records of *butleri*. Necker (1938), Ditmars (1939), Cagle (1941), A. G. Smith (1951), and Wright & Wright (1952) nevertheless presumed that the species was to be found in northeastern Illinois. Conant (1950) pointed out *T. butleri* was unknown in Illinois, although colonies exist in Wisconsin and southern Michigan. In view of the hundreds of garter snakes available from the Chicago area and the absence of specimens of *T. butleri*, I believe the species should be dropped from the list of Illinois reptiles.

Thamnophis sauritus sauritus (Linnaeus).—The evidence for deleting this subspecies is presented in the discussion of geographic variation of *T. s. proximus* on page 226.

Thamnophis sirtalis parietalis (Say).—The evidence for deleting this subspecies is given under the discussion of geographic variation of *T. s. sirtalis* on pages 231–2.

Natrix rigida (Say).—Davis & Rice (1883a), Jordan (1888), and Wright & Wright (1952) mentioned Illinois in defining the range of this Gulf Coast water snake. It is almost certain that Davis & Rice misidentified a specimen of *N. grahami* or *N. septemvittata* and that, on their authority, other authors listed the species as occurring in the state.

Natrix sipedon fasciata (Linnaeus).—The inclusion of this name in the Illinois literature is probably due to the confusion in

the nomenclature of *N. sipedon* races rather than to misidentification of specimens. Hurter (1911), Löding (1922), and Haltom (1931) apparently applied the name *fasciata* to the race now known as *confluens*; Davis & Rice (1883a), H. Garman (1892), Gaige (1914), and Wright & Wright (1952) to the race now known as *pleuralis*. *N. s. fasciata*, as now understood, does not occur north of Louisiana in the Mississippi valley.

Micrurus fulvius subsp.—Ditmars (1939) and Cagle (1941) recorded the coral snake as occurring as far north as southern Illinois. Pope (1944a) excluded Illinois from the range of the species. Perkins (1949) noted that a dubious record of *M. f. fulvius* exists from southern Illinois. Although there are old records for the coral snake in Ohio and Indiana, Conant (1951) and Link (1951) have shown rather conclusively that these specimens were probably transported from more southern localities.

One specimen (SIU 440) labeled "Cairo" is in the collection of Southern Illinois University. This example, a female with a total length of 513 mm., has 15 scale rows, 209 ventrals, 40 caudals, 7 upper and lower labials per side, 11 black body bands, and 3 black tail rings. No other data accompany the specimen except "Cairo" on an outside label. Since the nearest unquestionable record for the species is in central Arkansas, I am inclined to believe that the specimen was probably collected farther south and subsequently placed in a bottle which happened to bear the label "Cairo."

Agkistrodon contortrix contortrix (Linnaeus).—The evidence for deleting this subspecies is presented in the discussion of geographic variation of *A. c. mokeson* on pages 266-7.

Sistrurus miliarius streckeri Gloyd.—A. E. Brown (1901) expressed the possibility that the pigmy rattlesnake might extend eastward to southwestern Illinois. Until the species is found in Illinois or at least adjacent localities in Missouri, it should not be included in the Illinois fauna.

Crotalus horridus atricaudatus Latreille.—The evidence for deleting this subspecies is presented in the discussion of geographic variation of *C. h. horridus* on page 271.

In addition to species credited to Illinois in the literature, I have seen specimens of such obvious waifs as the caiman and python.

Class AMPHIBIA

Salamanders and Frogs

Amphibians probably were derived from Crossopterygian fishes early in the Devonian Age. They share with the Crossopterygians a great many anatomical similarities; also, they possess numerous distinguishing characters, most of which are adaptations for a life on land rather than in the water. There are relatively few modern amphibians. The fossil record is sufficiently good to allow recognition of about 10 extinct orders in addition to the three living orders. Two subclasses of amphibians are recognized, the Lepospondyli and the Apsidospondyli. The subclass Lepospondyli contains two living orders, the Gymnophiona (caecilians of the tropics) and the Caudata (salamanders). The subclass Apsidospondyli contains one modern order, the Salientia (frogs and toads).

The relationships of the subclasses, orders, suborders, and families represented in Illinois may be summarized in the following synopsis.

Subclass LEPOSONDYLI.—Vertebral centra formed directly from mesenchyme; arcualia partially ossified.

Order CAUDATA.—Tail well developed; at least two limbs present.

Suborder CRYPTOBRANCHOIDEA.—

Angulare free; gill slits present; external gills absent.

Family CRYPTOBRANCHIDAE.—Large; flattened; wrinkled; free, fleshy flanges on limbs.

Suborder AMBYSTOMATOIDEA.—Angulare and articulare fused; gill slits and external gills usually absent in adult stage.

Family AMBYSTOMATIDAE.—Lungs and costal grooves present.

Suborder SALAMANDROIDEA.—Parasphenoid teeth present; gills usually absent in adult stage.

Family SALAMANDRIDAE.—Costal grooves and nasolabial grooves absent; vomeropalatine teeth in long, posteriorly diverging series.

Suborder PLETHODONTOIDEA.—Lungs absent; vomerine and palatine teeth usually present.

Family PLETHODONTIDAE.—Costal grooves and nasolabial grooves present.

Family AMPHIUMIDAE.—Limbs much reduced; toes 3-3 or less.

Suborder MUTABILIA.—Angular and prearticular fused; no maxillary bone; pterygoid and palatine teeth in continuous series.

Family PROTEIDAE.—Large aquatic salamanders, each with 3 pairs of bushy, red gills; toes 4-4; no nasolabial grooves.

Suborder MEANTES.—External gills present; no hind limbs.

Family SIRENIDAE.—Teeth absent; toes 4-0; margins of jaws with horny sheaths.

Subclass APSIDOSPONDYLII.—Vertebral centra formed from subdivision of the sclerotome; arcualia cartilaginous.

Order SALIENTIA.—Tail typically absent in adult stage; pelvic girdle and enlarged hind limbs modified for jumping.

Suborder ANOMOCOELA.—Sacral vertebrae procoelous, fused to coccyx; eight presacral vertebrae uniformly procoelous or amphicoelous.

Family PELOBATIDAE.—Cutting tubercle on metatarsus; cranial crests absent.

Suborder PROCOELA.—Sacral and presacral vertebrae uniformly procoelous; free urostyle; sacral vertebrae with two condyles.

Family BUFONIDAE.—Teeth absent; Bidder's organ in both sexes.

Family HYLIDAE.—Teeth present; intercalary cartilages and toe pads present.

Suborder DIPLASIOCOELA.—Eight vertebrae; sacral vertebrae biconcave; presacral vertebrae procoelous.

Family RANIDAE.—Vomerine teeth present; no transverse fold of skin on head; tympanum usually distinct; mouth large.

Family MICROHYLIDAE.—Vomerine teeth absent; transverse fold of skin behind head; tympanum usually invisible; head narrow and mouth small.

For ease in identification, the Illinois species of Amphibia are diagnosed in two large keys, the salamanders (the order Caudata) in one and the frogs and toads (the

order Salientia) in the other. Illinois representatives of these two orders may be separated as follows:

Tail absent in adult stage; hind legs conspicuously large and modified for jumping.

Order Salientia, p. 66

Tail present in adult stage; hind legs not conspicuously large and modified for jumping.

Order Caudata, p. 22

Order CAUDATA

Salamanders

Nineteen species and subspecies of salamanders occur in Illinois. Another species, *Amphiuma means* Garden, has been included in the key, as it may eventually be found in the southern part of the state.

Most salamanders are terrestrial as adults, fig. 9, and aquatic as larvae, but even the adults are chained to moist habitats by their susceptibility to desiccation. A few salamanders remain in water throughout their lives; these are permanently gilled species, which are termed neotenous. The species occurring in Illinois range in size from the 4-inch *Hemidactylum* to the 24-inch *Cryptobranchus*. Most species are nocturnal; they remain hidden under logs or rocks during the day and come forth to search for food at night, when the relative humidity is higher. Salamanders are predatory, feeding chiefly on those invertebrates most readily available. They are rather sluggish in their movements and harmless to man. Their defense when captured consists of secreting slime. Some salamanders, like lizards, readily lose their tails, which they use as means of escape. While a predator is occupied by a detached, wriggling tail, the animal to which the tail belonged may escape by crawling away. A few salamanders can climb; some can jump by violently uncoiling their bodies.

Typically, the seasonal life history of salamanders begins with a spring migration to a pond, the males usually preceding the females by a day or so. When the females arrive, a nuptial dance ensues, the males swimming over the females and nudging them from time to time. Males deposit sperm packets known as spermatophores on submerged sticks or vegetation, and the females receive these packets with their cloacal lips, fertilization thus being internal. The females attach their eggs, each surrounded

by concentric layers of jelly, to vegetation or debris in the water. In a few days to several weeks, gilled larvae hatch from the eggs and each larva rather quickly develops four legs. Typically, metamorphosis occurs in a few months. The newly transformed adults are difficult to identify for a few days before the characteristic features of mature adults appear.

There are several departures from this typical life cycle. At least one species practices external fertilization, the male depositing sperm over the newly laid eggs in the manner of most fishes. Some species differ in having a fall mating and fall oviposition. It is not certain that in all species the female picks up the entire spermatophore, and it is probable that in some species sperm cells escape from the packet and swim into the vent of the female salamander. In a few species the eggs are laid near a stream or pond, and the hatchlings must crawl to water or wait until the hatching site is flooded by rains. The most striking deviation from the typical life cycle is found in the genus *Plethodon*. In all species of this genus, the larval period is spent within the large eggs, which are deposited in rock crevices or rotten logs on land. At hatching the miniature salamanders are ready for a terrestrial existence. Other variations in life histories are noted in the habits sections of the following species accounts.

Eight of the 19 Illinois salamanders are predominantly eastern in distribution, occurring in Illinois in the Wabash Border counties and in some cases extending varying distances northward or southward in the Mississippi River valley but circumventing the central prairie. One of the eastern species, *Desmognathus fuscus*, has apparently entered Illinois via the Mississippi River valley, since the nearest record outside Illinois is in western Kentucky rather than Indiana. The eight eastern components are *Cryptobranchus alleganiensis*, *Ambystoma maculatum*, *A. opacum*, *Eurycea bislineata rivicola*, *E. longicauda longicauda*, *Plethodon dorsalis*, *P. glutinosus glutinosus*, and *Desmognathus fuscus*.

Three species, *Ambystoma texanum*, *A. tigrinum*, and *Eurycea longicauda melanopleura*, have ranges centering to the west of Illinois. The first two species are relatively wide ranging and they completely traverse Illinois. The third is an Ozark

species found only in the extreme western part of the state.

Three species, *Ambystoma talpoideum*, *Notophthalmus viridescens louisianensis*, and *Siren intermedia nettingi*, are clearly southern animals. The first species extends northward along the Mississippi River to the southern tip of the state; *Siren* extends northward along the major rivers in the southern two-thirds of Illinois; *Notophthalmus* occurs as far north as the northern boundary of the state.

Three species, *Ambystoma laterale*, *Plethodon cinereus cinereus*, and *Hemidactylium scutatum*, northern in distribution, extend southward into Illinois.

Two species cannot be classified according to distribution. *Necturus maculosus maculosus* has a range in which Illinois is approximately centered. *Eurycea lucifuga* is unassignable because of the peculiar restriction of this species to areas containing limestone caves.

Key to the Order Caudata (Salamanders)

1. One pair of legs (Sirenidae)
 *Siren intermedia nettingi* 2
2. Legs vestigial; 3 or fewer toes; body eel-like (Amphiumidae)
 *Amphiuma means tridactylum* 4
- Legs well developed; 4 or more toes; body not eel-like 3
3. Four toes on each hind foot 4
 Five toes on each hind foot 5
4. Feathery external gills; total length to 18 inches (Proteidae)
 *Necturus maculosus maculosus* 4
- No external gills; total length less than 4 inches (Plethodontidae)
 *Hemidactylium scutatum* 5
5. Body flattened and longitudinally wrinkled; one gill slit on each side of neck; toes with free fleshy margins, fig. 10 (Cryptobranchidae) *Cryptobranchus alleganiensis alleganiensis* 6
- Body terete, not wrinkled; no gill slits; toes without fleshy flanges 6
6. Costal grooves present, fig. 9
 Costal grooves absent (Salamandridae)
 *Notophthalmus viridescens louisianensis* 7
7. Nasolabial grooves absent, fig. 11 (Ambystomatidae) 8
 Nasolabial grooves present, fig. 12 (Plethodontidae) 16
8. Premaxillary teeth in two or more series; neck distinctly wider than head; lingual plicae at oblique angles to median longitudinal furrow, fig. 13
 *Ambystoma texanum* 16

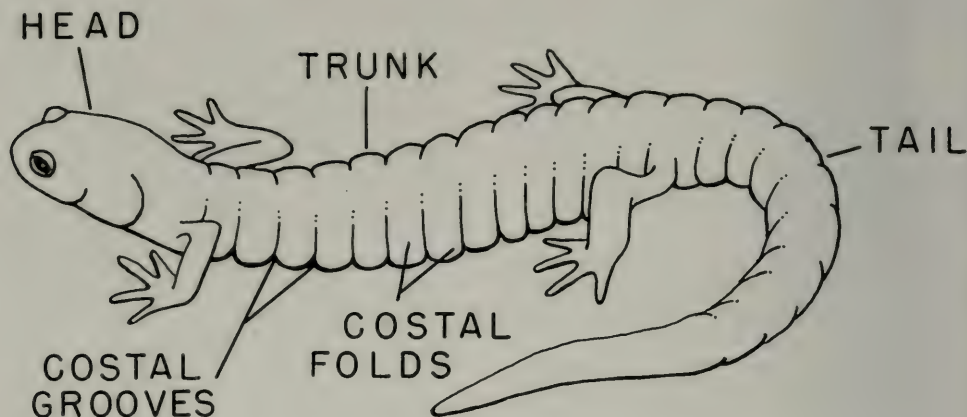
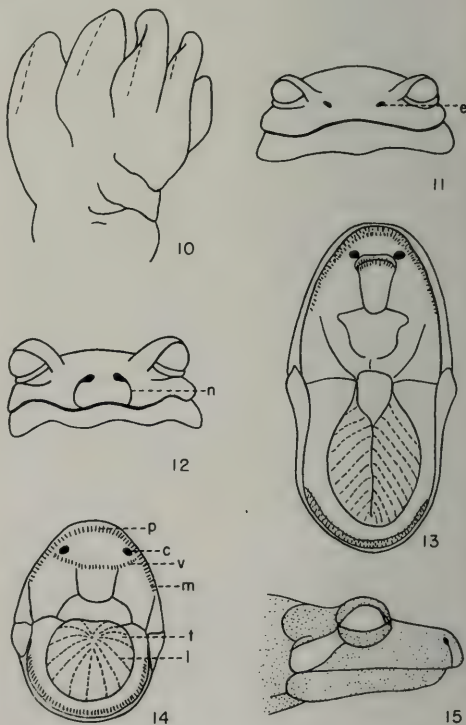


Fig. 9.—Lateral view of a salamander, *Ambystoma texanum*.

- Premaxillary teeth in a single series; head wider than neck; lingual plicae radiat., fig. 14 9
9. Pattern consisting of 4 to 8 silvery white crossbands on dorsum
..... *Ambystoma opacum*
- Pattern not consisting of white crossbands 10
10. Body long and slender; toes of adpressed limbs barely overlapping.
..... *Ambystoma laterale*
- Body stout; toes of adpressed limbs overlapping by length of longest finger or more 11
11. Groundcolor black or brown, with yellow spots 12
- Groundcolor black or brown, without yellow spots 13
12. Two dorsolateral rows of subequal yellow spots; venter and lower sides brown and unspotted *Ambystoma maculatum*
- Irregularly spaced and unequal yellow spots on back and sides and often on venter... *Ambystoma tigrinum tigrinum*
13. Head width 23 per cent or more of snout-vent length *Ambystoma talpoideum*
- Head width less than 23 per cent of snout-vent length 14
14. Snout-vent length over 50 mm.; back dark or with brassy flecks
- Immature *Ambystoma tigrinum tigrinum*
- Snout-vent length under 50 mm.; back dark and with or without flecks 15
15. Dorsum brown, often with brassy flecks; venter yellow or white
..... Immature *Ambystoma maculatum*
- Dorsum black or brown, often with irregular white blotches; venter brown
Immature *Ambystoma opacum*
16. Light line from eye to angle of jaw, fig. 15; tail triangular in cross section
..... *Desmognathus fuscus conanti*
- No light line from eye to angle of jaw; tail not triangular in cross section 17
17. Tongue with a central pedicel, free all



Figs. 10-15.—Characteristics of salamanders: 10, hind foot of *Cryptobranchus alleganiensis*; 11, face view of *Ambystoma opacum*; 12, face view of *Plethodon glutinosus*; 13, open-mouth view of *Ambystoma texanum*; 14, open-mouth view of *Ambystoma opacum*; 15, head of *Desmognathus fuscus*; *c*, choana; *e*, external naris; *l*, lingual plica; *m*, maxillary teeth; *n*, nasolabial groove; *p*, premaxillary teeth; *t*, tongue; *v*, vomerine teeth. A dissecting microscope is necessary to see most of these structures.

- around; groundcolor of dorsum yellow, orange, or red; venter yellow or white 18
- Tongue attached in front, free behind and at sides; groundcolor of dorsum black, brown, or dark gray; venter gray, brown, or black 21
18. Three or more costal folds between adpressed limbs; yellow, with brown dorsolateral stripes
Eurycea bislineata rivicola
- Two or fewer costal folds between adpressed limbs 19
19. Body red or red-orange, with numerous irregular black spots or dashes scattered over back and sides *Eurycea lucifuga*
- Body yellow or orange-yellow, with distinct dorsolateral stripes 20
20. Sides of tail with many vertical dark bars
Eurycea longicauda longicauda
- Sides of tail dark and without vertical bars *Eurycea longicauda melanopleura*
21. Costal grooves 15 or fewer; belly uniform gray or black; back flecked with white; maximum length 180 mm.
Plethodon glutinosus glutinosus
- Costal grooves 16 or more; belly usually mottled; back not spotted with white; maximum length 110 mm. 22
22. Middorsal red, orange, or yellow longitudinal stripe 23
- No middorsal red, orange, or yellow stripe 25
23. Middorsal stripe zigzag in shape
Plethodon dorsalis
- Middorsal stripe with straight edges 24
24. Costal grooves 16-19, usually 17; tail usually less than snout-vent length; middorsal stripe usually widest on base of tail
Plethodon dorsalis
- Costal grooves 17-20, usually 19; tail usually longer than snout-vent length; middorsal stripe widest at mid-body
Plethodon cinereus cinereus
25. Fore legs and breast region with red suffusion; costal grooves usually 17 or 18; tail usually less than snout-vent length
Plethodon dorsalis
- Fore legs and breast region without red markings; costal grooves usually 18 or 19; tail usually longer than snout-vent length
Plethodon cinereus cinereus

CRYPTOBRANCHIDAE

This family contains two genera of large, permanently aquatic salamanders, one of which occurs in the Orient and the other in the eastern United States.

Cryptobranchus Leuckart

Two subspecies are currently recognized in this monotypic genus. The nominate race, which occurs in extreme eastern Illinois, is widespread in eastern North America; the other race is confined to Ozarkian

streams of southeastern Missouri and adjacent Arkansas.

Cryptobranchus alleganiensis *alleganiensis* (Daudin)

Hellbender

Salamandra alleganiensis Daudin 1803:231
(type locality: Allegheny Mountains in Virginia).

Cryptobranchus alleganiensis, Goodnight 1937:301.

Menopoma allegheniense, Davis & Rice 1883a:26.

Menopoma alleghaniensis, Brendel 1857:254.

Cryptobranchus alleghaniensis, H. Garman 1892:380-1.

Diagnosis.—A large aquatic salamander (largest Illinois specimen 440 mm. in total length), fig. 16, with a flattened, much wrinkled body; 5 toes on each hind foot; loose folds of skin along sides of body and posterior margins of legs; 1 gill slit on each side of throat; dark dorsum and slightly less dark venter; without external gills.

Variation.—Bishop (1941) found that males of this species were proportionately broader bodied and heavier than females. During the breeding season, the male can be recognized by the swollen ridge surrounding the vent.

Bishop (1941) believed that transformation occurs in the second year. The newly transformed hellbenders differ from large adults by their more prominent black spots.

Four Illinois specimens are extant. One of these, CAS 294, is obviously very old and is accompanied only by the label "southern Illinois." It is a female, 225 mm. in snout-vent length; although faded, it still has scattered inky flecks on the dorsum and sides of the tail. Three recent specimens, reported by Stein & Smith (1959), range from 267 to 285 mm. in snout-vent length, 418 to 440 mm. in total length; internarial distances are 2.0, 2.2, and 3.5 times the spiracular diameters. Two of the three are bluish slate in color; one is dirty brown; two are uniformly colored except for very faint mottling; one is minutely flecked with olive. One (from the Ohio River at Cave in Rock) has rather heavy pigmentation on the lower jaw and a spiracle diameter of only 4.5 mm. and thus approaches the Ozarkian race, *Cryptobranchus alleganiensis bishopi*. The others are in every way typical of the nominate subspecies; in dor-

sal pattern, one of the most reliable subspecific characters, all four Illinois specimens are assignable to *C. a. alleganiensis*.

Habits.—The hellbender is permanently aquatic, occurring in fast-running water of rivers and large creeks. Although essen-

twisted into a single rosary-like string. Egg masses deposited by several females may be found under one flat rock. The nest site may be attended by a male who aerates the eggs by his movements. Eggs laid in mid-September hatch in mid-November. Dur-



Fig. 16.—An adult *Cryptobranchus alleganiensis alleganiensis* from Harrison County, Indiana. (Photo by Isabelle Hunt Conant.) The groundcolor is slate gray; the scattered irregular blotches are black.

tially nocturnal, in the spring many of these salamanders are caught on baited hooks during the day. According to Bishop (1941), the lungs of the hellbender are well developed, and captive individuals rise to the surface at intervals to gulp air.

Hellbenders are ugly in appearance and unpleasant to handle because of their extreme sliminess. In food habits they are predatory, eating crustaceans, fishes, mollusks, insects, and even their own eggs and young.

Bishop (1941), who summarized the life history of *C. a. alleganiensis*, noted that in the eastern United States breeding aggregations are found in August. Fertilization is external. Approximately 300 to 400 eggs, each of which is about 6 mm. in diameter and surrounded by concentric rings of jelly, are laid in multiple strands, which become

ing the 2-year larval period, the young hellbenders, which are gilled, gradually acquire the characteristics of the adults.

Illinois Distribution.—Although *C. a. alleganiensis* was long presumed by many authors to occur in Illinois waters, actual specimens with locality data were not available until recently. Prior to 1900, the several references to the species apparently were based on hearsay records of fishermen and on the likelihood that the species occurred in the Ohio River down to the mouth of the Wabash River. Blatchley (1899) mentioned a Vigo County, Indiana, specimen presumably taken in the Wabash River.

Stein & Smith (1959) summarized and evaluated all of the reports for Illinois. Unquestionable recent records for the Ohio and lower Wabash rivers bordering Illinois indicate that the species occurs in the south-

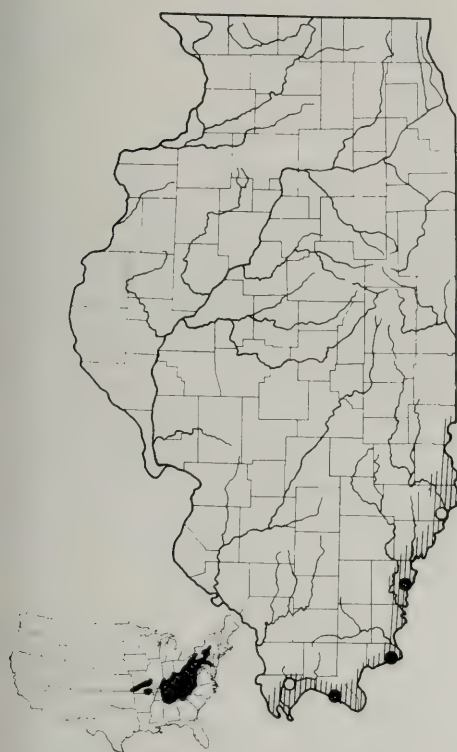


Fig. 17.—Distribution of *Cryptobranchus alleganiensis alleganiensis*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States. The Blatchley record referred to on page 26 is not plotted.

eastern part of this state and may ascend short distances up the major tributaries of the Ohio and Wabash rivers, fig. 17.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: LAWRENCE COUNTY: Lawrenceville, Wabash River at Vincennes [Indiana] (Stein & Smith 1959); PULASKI COUNTY: near Ullin (Stein & Smith 1959).

AMBYSTOMATIDAE

The family includes three genera in the United States and Canada, two of which are confined to the Pacific Northwest and one of which is transcontinental.

Ambystoma Tschudi

This North American genus contains 12 species known in the United States and Canada; several of these species consist of two or more subspecies. Six species and subspecies occur in Illinois.

Ambystoma laterale Hallowell Blue-Spotted Salamander

Ambystoma laterale Hallowell 1858:352 (type locality: borders of Lake Superior near Marquette, Michigan).

Ambystoma jeffersonianum laterale, Davis & Rice 1883a:26.

Ambystoma laterale, Minton 1954:178.

Ambystoma jeffersonianum nec Green, Davis & Rice 1883a:26.

?*Ambystoma jeffersonianum jeffersonianum nec* Green, Jordan 1888:178.

Ambystoma jeffersonianum nec Green, Hay 1892a:431.

Ambystoma jeffersonianum fuscum, H. Garman 1892:372-3.

?*Plethodon glutinosus nec* Green, Shelford 1913:181, 183.

Diagnosis.—A medium-sized, slender, dark brown, black, or blue-black salamander (largest Illinois specimen 124 mm. in total length), fig. 18, with discrete pale blue or bluish white flecks on venter, sides, and sometimes on the dorsum; usually 12 or 13 costal grooves, counting impressed lines in groin and axilla; toes of adpressed limbs separated or overlapping by no more than 1 costal fold; head of moderate size, distinctly wider than neck.

Variation.—Males of this species possess greatly swollen vents during the breeding season. At other times the sexes are difficult to distinguish. Minton (1954) noted that toes of adpressed limbs touch or overlap more frequently in males than in females.

The toes of the adpressed limbs touch or overlap by as much as 1 costal fold in specimens under 40 mm. in snout-vent length; toe tips vary from an overlap of one-half costal fold to a separation of as much as 3 folds in specimens over 40 mm. Juveniles are relatively larger headed than adults.

None of our specimens can be assigned to the related *Ambystoma jeffersonianum*. Inclusive of the impressed lines in the axilla and the groin, there are 12-12 costal grooves in four specimens, 13-13 in eight specimens, and 14-14 in one specimen. Vomerine teeth

are usually in 4 series, but sometimes the median pair is fused. Vomerine tooth counts for four specimens range from 27 to 39, averaging 32. Maxillary and premaxillary tooth counts for five specimens range from

Stille (1954*b*) found that in the Chicago region the eggs of this species are laid singly or in small clumps attached to litter on the bottoms of the shallow forest ponds. Egg laying occurs in late March and early April.



Fig. 18.—An adult *Ambystoma laterale* from Lake County, Illinois. The groundcolor is black; vague bluish white flecks are scattered over the lower sides.

76 to 101, averaging 85. Nine of the 14 specimens at hand have discrete light flecks on the sides of their tails as well as on their venters. The tail length ranges from 40.4 to 49.5, averaging 46.5, per cent of the snout-vent length.

Habits.—Minton (1954) noted that this species is characteristic of wooded, swampy areas where the soil is sandy and that it may occur in patches of woodland that are surrounded by prairie. Like most salamanders, individuals of this species may be found under logs or other objects. They are above ground in numbers only during the short breeding season. Their food consists of arthropods and annelids.

Hatching occurs approximately a month later, and transformation takes place in late June to mid-August, the time depending on the permanency of the ponds. Reliable information on the life history of the blue-spotted salamander is not available; published observations concern the related *Ambystoma jeffersonianum* or refer to a composite of the two species.

Illinois Distribution.—This northern species is restricted in Illinois to the north-eastern corner of the state, fig. 19. Yarrow (1882*a*), who first reported it from Illinois, considered its range as state-wide. The reported occurrence of *A. jeffersonianum* (equals *A. laterale*) in southern Illinois is

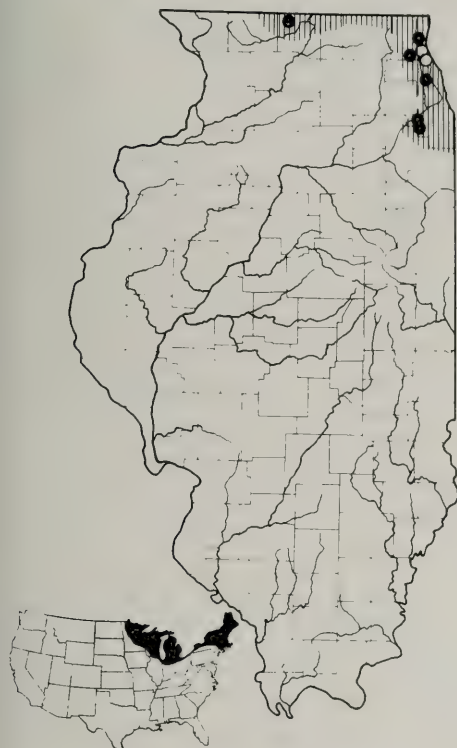


Fig. 19.—Distribution of *Ambystoma laterale*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

in error and actually is based on specimens of the superficially similar *A. texanum*. The occurrence of the species in the southern half of the state was not challenged by many subsequent authors, probably because of 48 USNM specimens from southern Illinois localities cataloged as *A. jeffersonianum*. I have examined these specimens (4096 [38] "S. Ill."; 8837, 12050 [3], 12056 [2], 12058-60 Mount Carmel; 8777 Belleville) and have found them to be *A. texanum*.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map, fig. 19, by hollow symbols: LAKE COUNTY: Beach, Highland Park (Schmidt & Necker 1935).

***Ambystoma maculatum* (Shaw)**
Spotted Salamander

Lacerta maculata Shaw 1802:304 (type locality: Carolina, revised to vicinity of Charleston, S. C., by Schmidt 1953).

Ambystoma maculatum, Schmidt 1930:10-1.

Ambystoma punctata, Kennicott 1855:593.

Ambystoma punctatum, Cope 1868:177.

Ambystoma punctatum, O'Donnell 1937:1066-7.

Diagnosis.—A large, stout, blue-black, slate-colored, or brownish black salamander (largest Illinois specimen 190 mm. in total length), fig. 20, with 2 rows of yellow-white or orange-yellow, usually rounded, spots extending from the head well onto the tail; sides and venter slate color to



Fig. 20.—A subadult *Ambystoma maculatum* from Alexander County, Illinois. The ground-color is dark brown or black; discrete yellow spots tend to be arranged in two rows down the back.

Table 2.—Ontogenetic variation in Illinois *Ambystoma maculatum*, as illustrated by a series from Alexander County. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	JUVENILE (8)		ADULT (11)	
	Range	Mean	Range	Mean
Snout-vent length (mm.)	35.2-45.0		59.0-79.0	
Snout-vent length as percentage of total length	51.0-60.0	55.0	48.3-52.4	50.0
Number of vomerine teeth	24-42	33.2	43-59	52.0
Number of premaxillary-maxillary teeth	91-117	102.5	108-140	129.0
Position of toe tips with legs adpressed	+ 2 - + 5		- 1 - + 2	

Table 3.—Geographic variation in adult Illinois *Ambystoma maculatum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHERN ILLINOIS (15)		EAST-CENTRAL ILLINOIS (4)		NORTHEASTERN ILLINOIS (10)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	59-80		67-80		74-101	
Total length (mm.)	112-167		154-170		165-190	
Vomerine teeth	38-59	51.0	35-64	47.5	39-70	55.5
Premaxillary-maxillary teeth	108-140	129.0	122-140	128.3	127-161	136.5
Body spots	9-17	13.0	11-15	12.7	14-16	15.7
Costal grooves	11-13	11.8	11-12	11.2	12-13	12.4

brown without irregular yellow spots or blotches; usually 12 costal grooves, sometimes 11 or 13; 1 or no palmar tubercles.

Variation.—During the breeding season the male of *Ambystoma maculatum* has a greatly swollen vent and darker colored venter. At other seasons, according to Bishop (1941), the female may be recognized by a wider, more convex head, greater distance between the fore and hind legs; and a shorter tail.

Juveniles have smaller dorsal spots than adults. In specimens less than 40 mm. from snout to vent, the spots are less regularly arranged, less prominent, and no greater in size than the eyes. Specimens 45 mm. in snout-vent length and larger have conspicuous yellow spots against a dark ground-color, and the individual spots are larger than the eyes. The chins and venters are yellowish white in juveniles, becoming dark brown or slate color in adults. Also, juveniles differ from adults in having proportionately longer legs, shorter tails, and smaller numbers of teeth. This variation is summarized in table 2.

Although meager, the series available for study indicate some geographic variation

within the state. Ten adults from northeastern Illinois (Lake County) average considerably larger in size, possess more teeth and a higher number of body spots, and have a slightly higher average costal groove count than specimens from elsewhere in the state. An occasional specimen has a pair of bright orange spots on the head that are in sharp contrast to the yellow body spots. Salamanders from other parts of the state sometimes have orange spots on their heads, but the color difference is less conspicuous than in the northeastern specimens.

The large number of vomerine and premaxillary-maxillary teeth may be directly correlated with the large size of the northern salamanders. The other slight differences suggest that two subspecies may be discerned eventually in *A. maculatum*. Intrastate variation in the species is summarized in table 3.

Habits.—According to Pope (1944*b*), *A. maculatum* is common in deciduous and mixed woods in northeastern Illinois. Cagle (1942*a*) reported that it is abundant in low oak-hickory forests adjacent to swamps and creeks in southern Illinois. The species can be found in numbers throughout the

summer under logs in the swampy floodplain forest at Horseshoe Lake in Alexander County, where the numerous shallow woodland ponds seemingly afford ideal breeding sites. The spotted salamander remains hidden under logs or rocks during the day but may be found wandering about on the forest floor at night. It feeds on arthropods, mollusks, and annelids.

Early in the spring spotted salamanders migrate to a woodland pond to congregate and breed. The aggregation performs a sort of nuptial dance, after which the males deposit spermatophores on sticks and other litter, and the females lay eggs in clusters, usually of several dozen, on debris and vegetation in the pond. The eggs hatch in less than a month, and the larvae transform between late June and mid-August.

Illinois Distribution.—The spotted salamander is found in wooded regions in northern, eastern, and southern Illinois, fig. 21. Like that of many other eastern forest animals, the range of the species in Illinois is bisected by the Grand Prairie, and populations extend short distances northward from the south and southward from the north in the forested Mississippi River valley in western Illinois, but apparently they do not meet. In eastern Illinois the distribution is sporadic; permanent woodland ponds are necessary for the occurrence of *A. maculatum*. A record (UIMNH 1745) from Urbana, which is in a prairie region, is open to some doubt.

The general occurrence of this salamander from the Gulf Coast to well into Canada indicates that temperature is less important as a controlling factor than the presence of mesic forest. Although the forested areas in central Illinois appear to afford suitable habitat, they tend to become dry in late summer; there is no evidence that the species occupies these regions. The published record for Macoupin County (Owens 1941) is a misidentification based on two CNHM specimens that are actually *A. tigrinum*.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Palos Park (Schmidt & Necker 1935); Northfield (Cope 1868); DU PAGE COUNTY: Wooddale (Stille & Edgren 1948); UNION COUNTY: Anna (Cagle



Fig. 21.—Distribution of *Ambystoma maculatum*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

1942a); Union County State Forest (Minton & Minton 1948); WABASH COUNTY: Mount Carmel (Yarrow 1882a).

Ambystoma opacum (Gravenhorst) Marbled Salamander

Salamandra opaca Gravenhorst 1807:431 (type locality: New York).

Ambystoma opacum, Cope 1868:175.

Ambystoma opacum, Hurter 1911:78.

Diagnosis.—A medium-sized, stout, black salamander (largest Illinois specimen 121 mm. in total length), fig. 22, with 3 to 8 silvery to grayish white crossbands on the back and 4 to 8 white rings around the tail; dorsal crossbands widened laterally, usually forming a pair of dorsolateral light stripes; head wide; toes of adpressed limbs touching to broadly overlapping.



Fig. 22.—An adult *Ambystoma opacum* from Union County, Illinois. The groundcolor is black; the crossbands are white.

Variation.—Males of this species can be distinguished from females by the silvery white crossbands which contrast more sharply against the blue-black groundcolor than do the grayish white bands of the females. In preserved specimens the prominently swollen vent of the male, which is larger than that of the female at all seasons, offers the simplest method of determining the sex.

Subadults less than 30 mm. from snout to vent are usually quite unlike adults in pattern. The chins and venters are light brownish to light slate color, and the dorsal patterns consist of occasional, poorly defined, light blotches on the black groundcolor and often white "frosting" on the heads and anterior parts of the bodies. The adpressed limbs of this size group overlap by 2 or 3 costal folds. Specimens 30 to 35 mm. in snout-vent length have essentially the patterns of the adults except that the white crossbands anteriorly are less well defined; the venters are blue-black, and the brown or gray chins show evidence of darkening. Specimens 40 to 47 mm. in snout-vent length are proportionately shorter-legged, the adpressed limbs overlapping $1\frac{1}{2}$ to 1 costal fold. Individuals 48 mm. and larger in snout-vent length vary in the degree of overlap of adpressed limbs from 1 costal fold to barely touching. The number of teeth appears to vary with size of the individual.

No definite trends in geographic variation within Illinois have been discerned in this species. Individual variation for a sample of 41 specimens from southern and eastern Illinois is as follows: snout-vent length 32 to 59 mm.; total length 57 to 121 mm.; number of costal grooves 11 to 13 (average

12.1); toes of adpressed limbs varying from barely touching to overlapping by $3\frac{1}{2}$ costal folds; number of head and body bands 3 to 8 (average 5.8); number of tail rings 4 to 8 (average 6.2); number of vomerine teeth 29 to 63 (average 48.0); number of premaxillary-maxillary teeth 79 to 147 (average 110.0).

Habits.—*Ambystoma opacum* is a woodland animal, more tolerant of aridity than *A. maculatum* but apparently less tolerant of low temperatures. Since fall and winter rains insure floodplain pools that last long enough for the transformation of the *opacum* larvae, a suitable breeding site is probably less important as a limiting factor for this species than for *maculatum*.

The marbled salamander is usually found in wooded hilly regions and can be collected under rocks and logs throughout the summer, sometimes in surprisingly dry situations. In September individual salamanders migrate onto floodplains or into swamps and may be found, often in abundance, under logs or sticks, in heavily shaded areas subject to flooding with the autumnal rains. At Horseshoe Lake, Alexander County, however, the species is extremely abundant throughout the summer, and it appears at least as successful there, in the floodplain swamps, as in upland areas.

The food of the marbled salamander consists of arthropods, annelids, and mollusks.

The courtship of this species is similar to that of the spotted salamander, except that it takes place in the fall rather than in the spring and on land rather than in the water. The males deposit spermatophores in damp places, and the females pick them up with their cloacal lips; then each female

deposits approximately 100 eggs in a protected depression. Incubation depends on the length of time before the eggs are inun-

dated, and the hatching time is accordingly variable. Normally, metamorphosis occurs the following June or July.

Illinois Distribution.—*A. opacum* occurs throughout the southern third of Illinois, north along the Indiana-Illinois border probably to Iroquois County, fig. 23, but it appears to be abundant only in the southern fourth of the state.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: RANDOLPH COUNTY: (Hurter 1911); UNION COUNTY: Cobden (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882a).

Ambystoma talpoideum (Holbrook)
Mole Salamander

Salamandra talpoidea Holbrook 1838:117, pl. 39 (type locality: sea islands on the border of South Carolina).
Amblystoma talpoideum, Cope 1868:173.
Ambystoma talpoideum, Hay 1892a:582.

Diagnosis.—A medium-sized, extremely stout, broad-headed salamander (largest Illinois specimen 114 mm. in total length), fig. 24, blue-black or brownish black and usually unmarked above except for a suggestion of a longitudinal light stripe on the basal third of the tail; usually 11 costal grooves, counting the impressed line above the hind limbs; head width 22 to 32 per cent of the snout-vent length; snout-vent length 52 to 58 per cent of total length; toes overlapping when legs are adpressed; midventral dark stripe usually conspicuous.



Fig. 23.—Distribution of *Ambystoma opacum*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Table 4.—Ontogenetic variation in Illinois *Ambystoma talpoideum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SNOUT-VENT LENGTH (MM.)					
	33-40 (5)		41-50 (4)		50-61 (7)	
	Range	Mean	Range	Mean	Range	Mean
Total length (mm.)	58-72	.....	78-89	.....	91-114	.....
Costal folds overlapped by adpressed limbs	4-6	5.1	2.5-4.0	3.3	0.5-2.5	1.6
Vomerine teeth	36-40	38.5	40-49	43.2	39-65	52.5
Premaxillary-maxillary teeth	82-101	91.4	101-115	107.3	102-124	115.0
Head width as percentage of snout-vent length	26.4-32.1	28.2	26.1-28.8	27.2	22.4-25.5	24.5

Variation.—During the breeding season *Ambystoma talpoideum* males may be distinguished from females by their swollen vents. I have not been able to find external characters for sexing specimens taken at other seasons.

Young individuals are proportionately longer-legged, are wider-headed; are more bluish in color, are more often flecked with gray, and have fewer teeth than adults. These trends are summarized in table 4.

Bishop (1941) recorded the maximum length for this species as 97 mm. Four of the 16 Horseshoe Lake, Alexander County, specimens exceed that length, and INHS 5267 is 17 mm. longer than Bishop's largest specimen. Costal groove counts are 11–11 in 14 specimens and 10–10 in two specimens. Variation in dentition and body proportions is shown in table 4. The usual color is blue-gray, but occasionally large specimens

are gray-brown. The midventral dark longitudinal stripe may be margined on either side by a light area and a secondary dark lateroventral stripe. In most living specimens the dorsal portion of the base of the tail is lighter than the rest of the body.

Comparative material from South Carolina and Louisiana, lent through the courtesy of the late E. B. Chamberlain and of F. R. Cagle, agrees rather closely in most details with Illinois samples. Larvae and adults in the series from South Carolina have a somewhat more prominent ventral pattern, and two of the three Louisiana specimens are at variance with both the Illinois and the South Carolina series in the presence of numerous minute tubercles on the sides of the tails, a condition suggestive of sexual dimorphism.

Habits.—The mole salamander is apparently similar to the marbled salamander in



Fig. 24.—Adult *Ambystoma talpoideum* from Alexander County, Illinois. The groundcolor is dark brown or bluish black; the flecks and often the dorsal crest of the tail are gray.



Fig. 25.—Distribution of *Ambystoma talpoideum*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species as currently known.

habits, as the two species have been found together within or under rotten logs in cypress swamps. Although as many as five specimens of *A. talpoideum* have been collected in one day at Horseshoe Lake, Alexander County, this species is decidedly less common than *A. texanum*, *opacum*, or *maculatum*. *A. talpoideum* presumably feeds upon worms, mollusks, and arthropods.

Life-history data for this species in Illinois consist of one observation of a breeding aggregation on November 8. Mosimann & Uzzell (1952) report that in South Carolina oviposition occurs in late December and that the 10 to 41 eggs are in compact masses attached to small sticks and grass stems in shallow ponds. The larval stage is of approximately 3 to 4 months duration.

Illinois Distribution.—*A. talpoideum*, an uncommon species, is known at present in Illinois only from Alexander, Jackson, Johnson, and Union counties, fig. 25. I have examined the specimens reported by Cagle (1942a) from near Anna and 6 miles southwest of Jonesboro (CAS 2512 and 2002) and have found them to be *A. texanum*.

The range of *A. talpoideum* is yet to be delineated in the Mississippi River valley.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: ALEXANDER COUNTY: Cairo (Cope 1868).

Ambystoma texanum (Matthes) Small-Mouthed Salamander

Salamandra texana Matthes 1855:266 (type locality: woods near Colorado River and Cummings Creek bottom, Fayette County, Texas; revised to Rio Colorado bottomland by Schmidt 1953).

Ambystoma texanum, Stejneger & Barbour 1933:7.

Amblystoma microstomum, Cope 1868:207.

Ambystoma microstomum, Hurter 1911:73.

Chondrotus microstomus, Cope 1889:101-3.

Ambystoma jeffersonianum nec Green, Hay 1892a:431 (part).

Amblystoma jeffersonianum jeffersonianum nec Green, Yarrow 1882a:50.

Amblystoma jeffersonianum platineum nec Cope, Yarrow 1882a:151.

Ambystoma talpoideum nec Holbrook, Cagle 1942a:175 (part).

Diagnosis.—A moderate-sized, slate-colored, blue-black, or brownish black salamander (largest Illinois specimen 171 mm. in total length), fig. 26, often with lichen-like patches of gray on the sides of the tail and trunk; head narrow and mouth small; gular region conspicuously swollen and wider than greatest width of head; vomerine teeth less than 35 and never extending laterally beyond the choanae; maxillary-premaxillary teeth usually in 2 or more rows in front, the continuous series containing less than 100 teeth; toes of adpressed limbs touching in subadults or separated by 1 to 4 costal folds in large adults; costal grooves 13 to 15.

Variation.—Males of *Ambystoma texanum* have prominently swollen vents during the breeding season. At all seasons, they are slightly smaller and have longer tails, stouter legs, and wider heads than females.



Fig. 26.—An adult *Ambystoma texanum* from Calhoun County, Illinois. The groundcolor is dark brown or black, usually with flecks of gray scattered over the back and sides of the animal.

Trends in ontogenetic variation are expressed chiefly by proportions and color and are illustrated by a sample of 22 specimens from Horseshoe Lake, Alexander County, table 5.

Geographic variation within Illinois is rather slight. A sample (14 specimens) from the southern tip of the state tends to have smaller individuals, slightly lower tooth counts, and perhaps a higher frequency of subadults with distinct gray frosting on the dorsum than samples from elsewhere in the state. In 32 per cent of the 14 southern Illinois specimens a single row of premaxillary teeth is characteristic, whereas in only 6 per cent of 37 specimens from other parts of Illinois is a single row characteristic; 2 or 3 rows are typical.

Individual variation for a sample of 51

adults is as follows: snout-vent length 50 to 90 mm.; total length 89 to 155 mm.; number of costal grooves 13 to 15 (average 14.2); number of vomerine teeth 18 to 33 (average 25.0); number of maxillary-premaxillary teeth 58 to 101 (average 75.0). A specimen from McLean County has a bifid tail, an anomaly due to an injury to the tail of the animal.

Habits.—The small-mouthed salamander is the most common *Ambystoma* in the state. It occurs in woodlands, prairie, pastured areas, and even in the intensively cultivated black soils of central Illinois. Adults are encountered during the summer months in various habitats, such as rocky hillsides, creek beds, and floodplain swamps. They feed on earthworms, slugs, and arthropods. They are nocturnal and fossorial.

Table 5.—Ontogenetic variation in Illinois *Ambystoma texanum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SNOUT-VENT LENGTH (MM.)		
	33-40 (9)	41-54 (7)	56-64 (6)
Snout-vent length as percentage of total length.....	55.6-59.5	52.3-57.0	49.8-58.0
Toes of adpressed limbs.....	Touch	—½	— 2½
Number of vomerine teeth.....	15-27	20-26	18-27
Number of maxillary-premaxillary teeth.....	32-73	61-77	61-72
Color of venter.....	Light	Light or dark*	Dark

*Preserved specimens of this size group frequently have sharply bicolored sides.

Breeding occurs in late February and throughout March in most of Illinois. Almost any standing water is apparently suitable as a breeding site inasmuch as eggs have been observed in ditches, flooded fields, woodland streams, and even in cisterns. The egg masses, each usually consisting of 6 to 30 eggs, are deposited on sticks or vegetation in shallow water. Often eggs and spermatophores are present on the same object. The eggs hatch in a few days, the time depending upon the temperature of the water. The larvae transform into adults from late May through July.

Illinois Distribution.—This species in Illinois occurs north to Henry and Kankakee counties, fig. 27, and it is abundant in both woodland and prairie regions. The apparent gaps in range in extreme western Illinois and south-central Illinois, as shown



Fig. 27.—Distribution of *Ambystoma texanum*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

on the map, are probably merely indicative of little field work in these regions during early spring. The absence of records from Adams County, a relatively well-collected area, is puzzling.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: 3 mi. N Carbondale (Cagle 1942a); KNOX COUNTY: Galesburg (H. Garman 1892).

Ambystoma tigrinum tigrinum (Green) Eastern Tiger Salamander

Salamandra tigrina Green 1825:116 (type locality: near Moorestown, N. J.).

Amblystoma tigrinum, Cope 1868:183-4.

Ambystoma tigrinum, Hurter 1911:75.

Ambystoma tigrinum tigrinum, Dunn 1918:457.

?*Ambystoma lurida*, Kennicott 1855:593.

?*Amblystoma copianum*, H. Garman 1892:215.

Ambystoma maculatum nec Shaw, Owens 1941:183.

?*Ambystoma* sp., P. W. Smith 1951:192.

Diagnosis.—A rather large, blue-black or brownish black salamander (largest Illinois specimen 330 mm. in total length), fig. 28, with irregularly arranged yellow blotches, which are unequal and variously shaped, on the back and sides; costal grooves 12 or 13, sometimes 11 or 14; toes of adpressed limbs usually overlapping by 2 or more costal folds; 2 palmar tubercles distinct on freshly preserved specimens.

Variation.—In *Ambystoma tigrinum tigrinum*, the male differs from the female in having a longer vent and a longer tail. During the breeding season, the vent of the male is strongly protuberant.

Newly metamorphosed specimens, 50 to 60 mm. from snout to vent, are gray, brown, or olive, often with numerous indistinct dark spots above. Slightly older examples are black above, with a few very small yellow spots. The pattern of the adult is found in specimens 65 to 75 mm. in snout-vent length. The proportionate length of the legs decreases and the number of teeth increases with an increase in size. This variation is summarized in table 6.

No well-defined geographic variation within Illinois has been discerned for the eastern tiger salamander, although a difference in size between northern and southern specimens is indicated. Fifteen speci-



Fig.28.—An adult *Ambystoma tigrinum tigrinum* from Randolph County, Illinois. The groundcolor is dark brown or black; the yellow spots are irregular in size and arrangement. In some large adults the spots are obscured.

mens now available from the southern third of the state are less than 100 mm. from snout to vent, and numerous other examples observed but not preserved were well under this length. Fifteen specimens out of 49 now at hand from the northern half of Illinois exceed 100 mm. in snout-vent length. Pope (1944*b*) noted that the species attains its maximum size in the Chicago area. The largest specimen known

(330 mm. in total length) is from Quincy, Illinois (Langebartel 1946). Lengths and costal groove counts for three samples are given in table 7.

There is considerable individual variation in markings. Several of the large individuals are so dark that the spotted patterns are barely discernible. Other specimens, usually smaller individuals, are boldly marbled with black and yellow. Three large

Table 6.—Ontogenetic variation in Illinois *Ambystoma tigrinum tigrinum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SNOUT-VENT LENGTH (MM.)					
	51-61 (8)	64-73 (9)	75-83 (8)	86-96 (11)	97-105 (10)	106-115 (7)
Total length (mm.) . . .	104-117	109-161	139-169	159-208	160-228	215-240
Costal folds overlapped by adpressed limbs . .	9-2½	4-2½	5-1	5-1	2½-1	2½-0
Vomerine teeth	38-55	33-59	44-64	48-74	43-83	52-79
Premaxillary-maxillary teeth	82-116	59-114	102-132	103-148	117-153	110-151

Table 7.—Geographic variation in Illinois *Ambystoma tigrinum tigrinum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHERN HALF OF ILLINOIS (7)		NORTHERN HALF OF ILLINOIS			
			EASTERN (22)		WESTERN (18)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	51-93	.....	61-112	.....	55-115	.....
Costal grooves	11-12	11.7	12-14	12.6	12-13	12.5

specimens from central Illinois are light olive, with black spots and mottling.

Habits.—Like the small-mouthed salamander, the tiger salamander is nocturnal and fossorial. Accordingly, it is seldom seen unless it is discovered under a log or rock, or within some steep-sided excavation. Although this salamander is not abundant, it persists in the most disturbed areas, often occurring within cities and in intensively cultivated regions. Its food consists of almost any kind of animal it can overpower. Captive salamanders of this species take earthworms and hamburger readily.

The number of individuals found abroad late in the fall suggests that a migration to the breeding ponds occurs at that season. Actual breeding, however, occurs early in the spring. Loose clusters of 25 to 100 eggs

are attached to objects on the bottom of a pond. The incubation period depends on the temperature, probably averaging about 3 weeks. The larvae grow rapidly and in central Illinois transform in July. At metamorphosis the larvae of this species are about twice the size of other *Ambystoma* larvae.

Illinois Distribution.—This species is state-wide in distribution, fig. 29, but not abundant except in areas with numerous ponds. In most parts of the state, specimens are usually found quite incidentally in basements, deep-sided ditches, submerged meter boxes, or similar pits. Many permanent ponds, either prairie or woodland, harbor the species; small forest-edge ponds are probably preferred.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Glenview (Necker 1939c); Northfield (Yarrow 1882a); LAKE COUNTY: Waukegan (Necker 1939c); LA SALLE COUNTY: La Salle (Burt 1935); MADISON COUNTY: (Hurter 1893); MASON COUNTY: SE Havana (Vestal 1913); MENARD COUNTY: Athens (Dunn 1918); MONROE COUNTY: (Hurter 1893); PEORIA COUNTY: (H. Garman 1892).

SALAMANDRIDAE

This family includes two genera in the United States and Canada; *Notophthalmus* occurs east of the Great Plains and *Taricha* on the West Coast.

Notophthalmus Rafinesque

Three species of this eastern North American genus are found in the United States and Canada. The species occurring in Illinois consists of several subspecies, but only one of them is found within this state.

Notophthalmus viridescens louisianensis (Wolterstorff) Central Newt

Diemictylus viridescens louisianensis Wolterstorff 1914:383 (type locality: New Orleans, Louisiana).

Triturus viridescens louisianensis, Schmidt & Necker 1935:62.

Diemictylus viridescens louisianensis, Brown 1950:24.

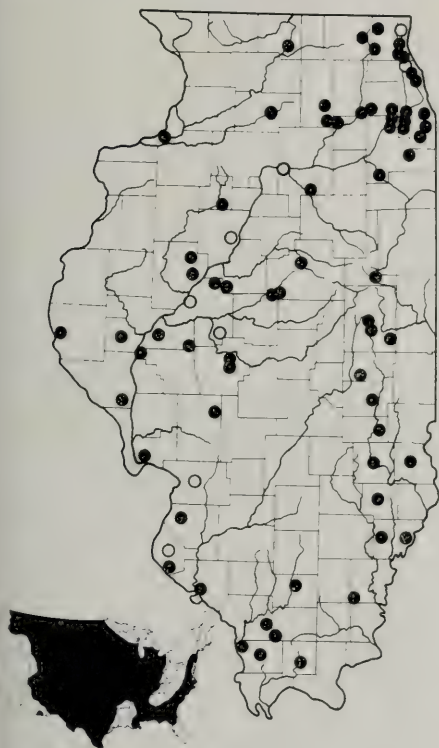


Fig. 29.—Distribution of *Ambystoma tigrinum*. The nominate subspecies occurs throughout the state. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Notophthalmus miniatus, Kennicott 1855:593.
Diemyctylus miniatus miniatus, Yarrow 1882a:161.

Diemyctylus viridescens miniatus, Hay 1887a:6.

Diemyctylus miniatus, H. Garman 1890:190.

Triton dorsalis nec Harlan, Brendel 1857:254.

Diemyctylus miniatus viridescens nec Rafinesque, Yarrow 1882a:161.

Diemyctylus viridescens, Hay 1887b:62.

Diemyctylus viridescens viridescens nec Rafinesque, Cope 1889:212-3.

Diemyctylus viridescens, Shelford 1913:252.

Notophthalmus viridescens viridescens nec Rafinesque, Stejneger & Barbour 1917:8.

Triturus viridescens, Dunn 1918:451.

Triturus viridescens viridescens nec Rafinesque, Stejneger & Barbour 1923:4.

Diagnosis.—A small, stout, aquatic or terrestrial salamander (largest Illinois specimen 104 mm. in total length), fig. 30, without costal grooves; gular fold poorly developed; cranial crests present; vomeropalatine teeth in two longitudinal series; dorsum yellow-brown, olive-green, or red-brown and sharply cut off from yellow of venter and lower sides; scattered black specks above and below; one or two dorso-lateral rows of small red dots, some of which are not margined with black or at

least not completely encircled. The eft, a peculiar terrestrial stage found only in this salamander, differs from adults, which are aquatic, by the absence of fins on the tail, by the absence of secondary sexual characters, and by the presence of a granular or warty skin and darker groundcolor.

Variation.—Efts are difficult to sex, but the depth of the pits in the temporal region (hedonic glands) serves to identify at least some males. Adults in breeding ponds are easily sexed. The male possesses greatly enlarged hind legs with horny material on the inner sides, a swollen cloaca, and conspicuous dorsal tail crest during the breeding season, in addition to the deep hedonic pits at all times. The female in the breeding season has dark, converging, cornified ridges on the lips of the cloaca.

No data on ontogenetic variation are available for the Illinois populations.

Most of the specimens extant are efts. No variation trends within Illinois have been discerned. Ten specimens from northeastern Illinois vary as follows: snout-vent length 18.8 to 40.2 mm.; total length 39 to 81 mm.; lateral red spots enclosed by black, 0 to 8 per side (average 2.3); lateral head



Fig. 30.—Adult *Notophthalmus viridescens louisianensis*, eft stage, from Monroe County, Illinois. The groundcolor above is dark brown or olive-brown; below, yellow.

stripe prominent in four specimens, weak in five, absent in one. Fourteen specimens from the southern third of the state exhibit the following variation: snout-vent length 18.2 to 45.2 mm.; total length 35 to 104 mm.; lateral red spots ringed with black, 0 to 9 (average 4.4); lateral head stripe prominent in 1 specimen, weak in 13.

Habits.—*Notophthalmus viridescens* has a rather complicated life history, as adults have both a terrestrial and an aquatic stage. Presumably the subspecies *louisianensis* and *viridescens* have essentially the same life cycle, which in *N. v. viridescens* includes an underwater nuptial dance and deposition of spermatophores and eggs in winter or early spring. The eggs, which are attached individually to submerged vegetation, hatch in 2 or 3 weeks, and the larvae transform usually in 2 or 3 months. The transformed newt is rather dry and warty-skinned. It soon loses its gills and fins; it is then called an eft. Because the eft lives under bark, logs, or rocks in typical salamander habitats, this is the form most often encountered in Illinois. After 2 or 3 years, the eft is sexually mature and ready for an aquatic existence. It develops fins and skin changes that permit aquatic respiration. The number of tiny efts that have been found in southern Illinois suggests that the initial aquatic stage may be shorter in *louisianensis* than the 2 or 3 months of *viridescens*. Newts eat a variety of invertebrates, mollusks being a particularly important item.

Illinois Distribution.—The central newt probably once occurred throughout the state except in the extreme western part. All recent records are for either the northern or for the southern fifth of Illinois, fig. 31. Although records for the central part of the state are at least 35 years old, there is little reason to doubt them, inasmuch as the central newt is easily recognized. It is likely that its occurrence in the area between extreme northern and southern Illinois was sporadic even before cultivation. The destruction of much of the forest, the draining of ponds and marshes, and the lowering of the water table probably accelerated the disappearance of this salamander from central Illinois.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COLES

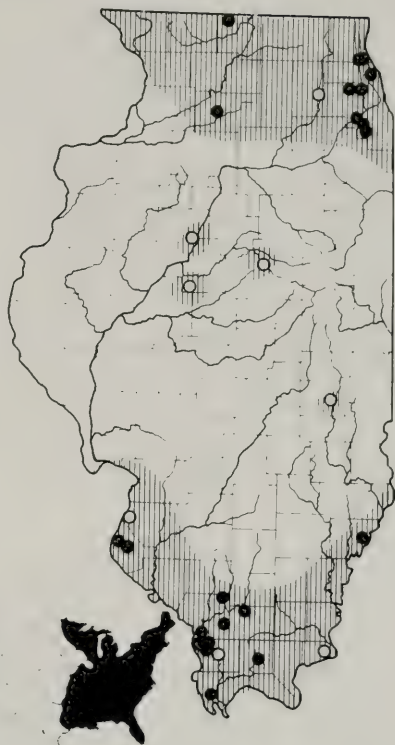


Fig. 31.—Distribution of *Notophthalmus viridescens*. Hatching indicates the presumed range of the subspecies *louisianensis* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

COUNTY: Charleston (Hankinson 1917); HARDIN COUNTY: Cave in Rock (H. Garman 1892); JACKSON COUNTY: Grand Tower (H. Garman 1892); KANE COUNTY: Geneva (H. Garman 1892); McLEAN COUNTY: Normal (Dunn 1918); PEORIA COUNTY: Peoria (H. Garman 1892); St. CLAIR COUNTY: Bluff Lake (Hurter 1893); TAZEWELL COUNTY: Delavan (H. Garman 1892); UNION COUNTY: Anna (Cagle 1942a).

PLETHODONTIDAE

Four of the 17 plethodontid genera known from the United States and Canada are represented in Illinois. The family is primarily New World in distribution but it is represented in Europe by one genus.

Eurycea Rafinesque

The genus *Eurycea* includes eight species, most of which have several subspecies. Three species occur within Illinois.

Eurycea bislineata rivicola Mittleman Midwest Two-Lined Salamander

Eurycea bislineata rivicola Mittleman 1949: 89-96 (type locality: Echo Canyon, McCormick's Creek State Park, Owen County, Indiana).

Eurycea bislineata bislineata nec Green, Dunn 1926:307.

Eurycea bislineata, Jordan 1929:218.

Spelerpes bislineatus, Davis & Rice 1883a:27.
Desmognathus fusca nec Rafinesque, Hankinson 1915:293.

Eurycea longicauda nec Green, Peters 1942: 182.

Diagnosis.—A small, slender, yellow or tan salamander (largest Illinois specimen 108 mm. in total length), fig. 32, with a lateral brown or black band of variable width

extending from the eyes almost to the tail tip; 13 to 15 costal grooves; $1\frac{1}{2}$ to 5 costal folds between the adpressed limbs; 6 to 22 vomerine teeth in two arched series behind and between the choanae; and usually either a median series of dark spots or irregularly spaced dark middorsal flecks.

Variation.—According to Bishop (1941), the male of this salamander differs from the female in its larger size, wider head, larger premaxillary teeth, and nasolabial tubercles. The teeth of the female at all times, and of the male from June to September, are said to be bicuspid.

Ontogenetic variation is not marked in the Illinois specimens available. The difference in ratio of tail length to total length, noted by Oliver & Bailey (1939) and Mittleman (1949), is apparent only when the figures are averaged. In 12 specimens 53 to 75 mm. in total length, the tail length ranges from 51.5 to 57.4 per cent (average 55.1) of the total length. In 12 specimens 85 to 108 mm. in total length, the tail length ranges



Fig. 32.—Adult *Eurycea bislineata rivicola* from Clark County, Illinois. The groundcolor is tan or yellow; the markings are dark brown.

Table 8.—Geographic variation in Illinois *Eurycea bislineata rivicola*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	PULASKI COUNTY (12)		POPE-GALLATIN COUNTIES (16)		CLARK-EDGAR COUNTIES (31)		VERMILION COUNTY (12)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	24-43		28-41		25-45		32-45	
Total length (mm.)	78-99		62-94		53-108		67-95	
Vomerine teeth			9-21	13.5	6-22	15.5	10-30	13.4
Costal folds between adpressed limbs	1-3	2.0	2-4½	2.9	1½-5	3.2	1½-3	2.4
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Costal grooves 15	0		12		4		0	
Costal grooves 14	67		44		48		75	
Costal grooves 13	33		44		48		25	
Stripes extending more than one-half tail length	100		100		85		75	
Unmarked dorsum	16		6		16		25	

from 53.6 to 61.0 per cent (average 57.0) of the total length.

The most apparent geographic variation among Illinois specimens is in color and pattern. The 16 specimens from Pope and Gallatin counties are the most strikingly marked, most of them having distinct spots middorsally on a clear yellow background. Viewed from the side they are sharply bi-colored, and the light spots in the lateral dark stripes are conspicuous. Forty-seven specimens from east-central Illinois are less prominently marked, the middorsal flecks being less discrete and the groundcolor more often tan or dirty yellow. Variation in additional characters for four samples is shown in table 8.

Habits.—The two-lined salamander may be abundant in small, rocky streams and in springs and seeps in mesic forest. In the latter habitat specimens are found by raking wet leaves along stream banks or by digging in wet shale banks bordering brooks. This salamander is slippery, surprisingly agile, and difficult to hold. Captive individuals run with considerable speed and are able to jump some distance. If placed in a terrarium, they quickly climb the glass sides, their moist bodies providing sufficient adhesion for them to stick to the glass surface. Arthropods and small worms are their chief food items.

During the month of May, the comparatively large eggs of this salamander may be found under flat rocks, submerged branches, or leaves. They are closely packed in a single layer of 12 to 30 per clump. Hatching occurs in approximately a month, and the larval period requires something more than a year.

Illinois Distribution.—This typically eastern salamander is apparently confined in Illinois to the Indiana-Illinois border and eastern portion of the Shawnee Hills, fig. 33. The distribution pattern suggests that even small prairies or areas of farmlands may be barriers, and the woodlands of the Southern Division are probably unsuitable because of aridity in summer and fall. The apparent absence of the species from the western counties of the Shawnee Hills is difficult to explain, inasmuch as the area contains numerous rocky streams and springs.

Mittleman (1949) plotted a record for the Starved Rock area but did not cite the locality in his list of material. La Salle County is west of our records, but it has seemingly good habitat for the species.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: COLES COUNTY: Charleston (Hankinson 1915).



Fig. 33.—Distribution of *Eurycea bislineata*. Hatching indicates the presumed range of the subspecies *rivicola* in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

Eurycea longicauda (Green)

Four subspecies of this eastern, stream-inhabiting salamander have been described, but only three are recognized in the present study. Two well-marked subspecies occur within Illinois.

Eurycea longicauda longicauda (Green)

Long-Tailed Salamander

Salamandra longicauda Green 1818:351 (type locality: New Jersey; revised to vicinity of Princeton by Schmidt 1953).

Eurycea longicauda, Stejneger & Barbour 1917: 19.

Eurycea longicauda longicauda, Cagle 1941:5.

Spelerpes longicaudus, Davis & Rice 1883a:27.

Eurycea longicauda pernix Mittleman 1942:

101-5, pl. 20 (along Jimmie Strahl Creek,

2½ mi. SE Nashville, Brown County State Park, Indiana).

Diagnosis.—A moderate-sized, slender, long-tailed salamander (largest Illinois specimen 153 mm. in total length), fig. 34, with yellow or orange-yellow groundcolor and brown or black maculations that tend to coalesce on the sides to form lateral bands; sides of tail with vertical dark bars; 13 to 14 costal grooves; toes of adpressed limbs overlapping by 2 costal folds or separated by 2 folds; 12 to 39 vomerine teeth in all; venter immaculate yellow; middorsum plain or more often with numerous dark spots clustered along the midline.

Remarks.—The recently described *Eurycea longicauda pernix* (Mittleman 1942) of unglaciated Indiana is said to differ from *E. l. longicauda* by a higher vomerine tooth count, more intense pattern, and greater development of sexual dimorphism. The holotype and allotype of *pernix* have, respectively, 27 and 32 vomerine teeth. Only 8.6 per cent of the Illinois specimens, exclusive of *E. l. melanopleura* intergrades, have 27 or more vomerine teeth. Tooth counts for 11 specimens, which should be referable to *pernix* on the basis of range (Brown, Jennings, Morgan, and Owen counties, Indiana), vary from 11 to 26 (average 19.6); similar counts for 6 specimens of *E. l. longicauda* from glaciated Indiana (Parke and Montgomery counties, Indiana) vary from 18 to 28 (average 22.2). Accordingly, a high number of vomerine teeth does not appear to be diagnostic for the population in unglaciated Indiana and Illinois.

I can discern no differences in development of secondary sexual characters or pattern which will separate specimens of *E. longicauda* from glaciated Indiana from those of unglaciated areas. There is a tendency for the lower sides of specimens from Maryland and Pennsylvania to have zones of small, well-separated spots, whereas the lower sides of salamanders from the Great Smoky Mountains and transmontane regions are vermiculate. It seems best to refer the Illinois populations to *E. l. longicauda*, pending a restudy of the species.

Variation.—External sexual differences in this salamander are slight. Bishop (1943) reported that the male has more swollen nasolabial tubercles than the female, a slightly papillose vent, a shorter tail, and toes almost meeting when the limbs are



Fig. 34.—Adult *Eurycea longicauda longicauda* × *melanopleura* intergrades from Monroe County, Illinois. The specimen at the left is fairly typical of the nominate subspecies; the specimen at the right shows some *melanopleura* influence in the coalescence of the dark bars on the sides of the tail and the spotting on the dorsum. The groundcolor ranges from lemon yellow to almost orange; the markings are dark brown or black.

adpressed. In the female the toes of the adpressed limbs are separated by at least 1 costal fold.

Subadults are quite different from adults in general appearance, possessing a clear yellow groundcolor, smaller middorsal spots, shorter tails, and fewer vomerine teeth. They usually have prominent dark spots on the anterior part of the chins, whereas adults usually have dusky chins. The ontogenetic variation in proportionate tail length and number of vomerine teeth is summarized in table 9.

Geographic variation for this subspecies in Illinois is manifested by intergradation with the western race, *E. l. melanopleura*. Populations of typical *longicauda* occur in the Wabash Border counties and throughout the Shawnee Hills. A slight influence of *melanopleura* is seen in the tendency for the vertical tail bars to coalesce in occasional specimens from western Union and Jackson counties. Samples from other Lower Mississippi Border counties exhibit a gradual replacement, south to north, of *longicauda* characters by those of *melanopleura*. The

Table 9.—Ontogenetic variation in proportionate tail length and in vomerine tooth counts in Illinois *Eurycea longicauda*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	TOTAL LENGTH (MM.)			
	54-84 (7)		133-155 (7)	
	Range	Mean	Range	Mean
Tail length as percentage of total length.....	51.9-61.0	57.3	60.8-64.7	63.0
Combined vomerine tooth counts.....	13-26	17.0	20-31	24.2

longicauda influence predominates as far north as St. Louis, but north of St. Louis specimens possess characters closer to those of *melanopleura*.

A single specimen (INHS), a juvenile, is known from the Wabash Border Division. This juvenile, 54 mm. in total length, has 14 costal grooves, a combined vomerine count of 16, 1 costal fold between toes of the adpressed limbs, a distinctly barred tail,

or outcrops by searching these areas with a flashlight. On rainy days, individuals are sometimes abroad and may be seen on trunks of trees. Normally, however, they remain hidden under rocks or logs or within crevices in bluffs during the day. Their food consists predominantly of arthropods.

Details of the life history of this subspecies are lacking, but they are probably similar to those of *E. bislineata rivicola*. Larvae

Table. 10.—Geographic variation in Illinois *Eurycea longicauda*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SHAWNEE HILLS (23)		UNION AND JACKSON COUNTIES (13)		MONROE AND RANDOLPH COUNTIES (20)		PIKE AND GREENE COUNTIES (18)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.).....	26.8–55.6		31.2–55.0		27.0–55.5		33.8–48.0	
Vomerine teeth.....	13–31	20	12–39	22	12–30	21	12–24	18
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Costal grooves 13...	100		100		90		7	
Costal grooves 14...	0		0		10		93	
Tail bars present...	100		100		85		22	
Middorsum plain or with median row of spots.....	100		77		50		6	
Middorsum with many scattered spots.....	0		23		50		94	
Venter plain.....	100		69		65		39	
Venter flecked.....	0		31		35		61	

and an unmarked middorsum. Geographic variation for a sample of *E. l. longicauda* from the Shawnee Hills and three samples of *E. l. longicauda* × *melanopleura* intergrades from the Upper and Lower Mississippi Border divisions is summarized in table 10.

Habits.—The long-tailed salamander occurs in abundance along rocky, swift streams in dissected, forested regions. It seems to be present in all of the areas in which this habitat occurs in the southern half of Illinois. *E. longicauda* does not occur in woodland seeps and springs without rock outcrops as does *E. bislineata*. Except for a more restricted habitat, *longicauda* is similar in habits and occurrence to *bislineata*. The species is nocturnal and can be found on boulders

of various sizes may be found throughout the winter months, indicating that the larval period probably requires 2 years. Transforming larvae can be found throughout the warm months in southern Illinois.

Illinois Distribution.—This salamander is a characteristic species of the Shawnee Hills division and it occurs sporadically in the Wabash Border, fig. 36. Apparently it is limited to wooded regions with relatively large areas of rock outcrop. The distribution is continuous up the river bluffs in the Lower Mississippi Border.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: ST. CLAIR COUNTY: Bluff Lake (Hurter 1893).

Eurycea longicauda melanopleura
(Cope)

Dark-Sided Salamander

Spelerpes melanopleurus Cope 1893b:383 (type locality: Raley's Creek, White River, Missouri).

Eurycea longicauda pernix $\times$ *E. l. melanopleura*, Mittleman 1942:104.

Eurycea longicauda melanopleura, Grimmer & Langebartel 1948:224.

Diagnosis.—A medium-sized, long-tailed salamander (largest Illinois specimen 130 mm. in total length), fig. 35, related to the subspecies *longicauda* but differing in having a longitudinal dark band (rather than a series of vertical bars) on each side of the tail, numerous middorsal dark spots scattered or arranged in several irregular rows, numerous dark flecks on venter, yellow-

green to yellow-brown groundcolor, and larger eyes.

Variation.—The males of the dark-sided salamander differ externally from the females in having more swollen snouts and larger nasolabial protuberances, but so many intermediate examples occur that dissection is often the only method by which the sex of an individual can be accurately determined.

In this subspecies subadults differ from older specimens less markedly than in *Eurycea longicauda longicauda* but in similar characters. Seven specimens, 88 to 114 mm. in total length, have tail lengths 48.0 to 65.5 (average 58.3) per cent of the total length, and six specimens, 115 to 130 mm. in total length, have tail lengths 58.5 to 65.2 (average 60.8) per cent. The groundcolor is usually more yellowish in small individuals,



Fig. 35.—An adult *Eurycea longicauda melanopleura* from Adams County, Illinois. The groundcolor ranges from greenish yellow to pure yellow; the markings are black or dark brown.

but the pattern is essentially the same. Some large specimens are suffused with fine flecks of darker pigment.

The Illinois population differs slightly from samples from more western localities in the smaller average number of vomerine teeth, in the poorly developed cirri, and in the usual irregularity of the rows of mid-dorsal dark spots. Nevertheless, the samples from western Illinois are homogeneous, quite distinct from the eastern *E. l. longicauda*, and the differences noted are not due to intergradation with the eastern form.

Thirteen specimens from Adams County show the following variation: snout-vent length 32.8 to 54.0 mm.; total length 88 to 133 mm.; 13 costal grooves in 3 speci-

mens, 14 in 10; toes of adpressed limbs overlapping by 1 costal fold to a separation of 2 folds; combined vomerine tooth counts 14 to 30 (average 20.5); cirri present in 1 specimen, nasolabial tubercles in 12; scattered ventral flecks in 11 specimens, immaculate venters in 2.

Intergrades of *melanopleura* $\times$ *longicauda* have been discussed under the subspecies *longicauda*. Samples from Pike and Greene counties display some characters of *longicauda* but the *melanopleura* influence is so pronounced that these specimens would key out as *melanopleura*.

Habits.—This subspecies is similar to the eastern long-tailed salamander in habits. The only difference that seems worthy of notice is the more frequent occurrence of *melanopleura* within caves.

Illinois Distribution.—This salamander is common in rocky streams, caves, and springs of the Mississippi River bluffs and dissected wooded uplands in Adams and Pike counties, fig. 36. Intergrading populations occur south to Union County, but only those populations north of St. Louis have the general appearance of *melanopleura*. The apparent absence of this subspecies north of Adams County may be due to temperature intolerance, inasmuch as apparently suitable habitat extends well north of the known distribution. The upper Illinois River valley appears to afford suitable habitat, but none of the subspecies of *E. longicauda* has been able to ascend this valley, probably because the lower portion lacks the requisite rocky streams.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: ADAMS COUNTY: 11 mi. S Quincy (Grimmer & Langebartel 1948).

Eurycea lucifuga Rafinesque

Cave Salamander

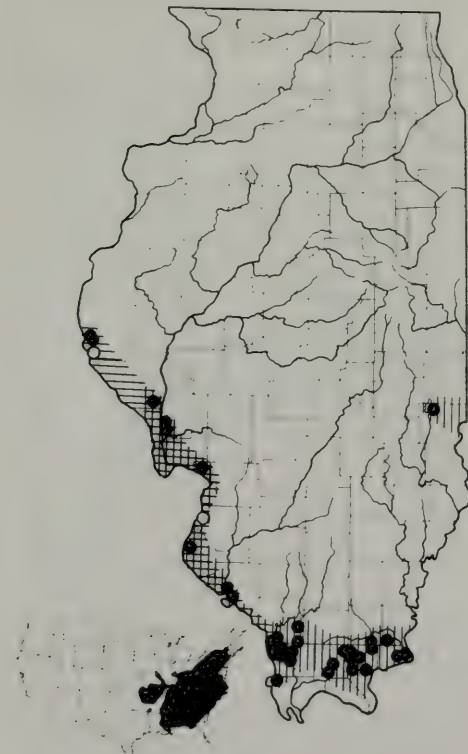


Fig. 36.—Distribution of *Eurycea longicauda*. Vertical hatching indicates the presumed range of *E. l. longicauda*; horizontal hatching, the presumed range of *E. l. melanopleura*; cross-hatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map shows the total range of the species in the United States.

Eurycea lucifuga Rafinesque 1822:3 (type locality: caves near Lexington, Kentucky); Stejneger & Barbour 1917:19.

?*Spelerpes ruber* nec Latreille, Hay 1887a:5. *Spelerpes ruber ruber* nec Latreille, Yarrow 1882a:157.

Spelerpes maculicaudus, Hurter 1911:86.

Diagnosis.—A medium-sized, slender, red or red-orange salamander (largest Illinois



Fig. 37.—An adult *Eurycea lucifuga* from Union County, Illinois. The groundcolor is bright red-orange; the markings are jet black.

specimen 159 mm. in total length), fig. 37, with numerous black spots scattered irregularly over the back and sides; 13 to 14 costal grooves; toes of adpressed limbs separated by $1\frac{1}{2}$ costal folds to an overlap of 2 folds; vomerine teeth usually in two J- or C-shaped series, the combined count ranging from 17 to 39.

Variation.—Males of this species can be distinguished from females by their more prominent nasolabial swellings, the presence of mental glands, the distinctly margined vents, and the slightly longer legs (an average of 1.08 costal folds between toes of adpressed limbs in 12 males and 0.47 costal fold in 18 females).

Newly transformed specimens are similar in general appearance to young *Eurycea longicauda*. The sides are dark gray, enclosing many light flecks, and the middorsal areas are yellow-gray, with scattered dark flecks. Slightly older specimens are yellow, with small black spots scattered over the backs and sides, differing from adults chiefly in the yellow ground color and the less conspicuous dorsal spots. Subadults differ in number of teeth and relative tail length. Seven subadults, 65 to 102 mm. in total length, vary in vomerine tooth counts from 18 to 28 (average 20.1) and the tail makes

up 52.9 to 58.3 (average 55.0) per cent of the total length. Ten large specimens, 128 to 159 mm. in total length, have 20 to 39 vomerine teeth (average 26.2), and the tail ranges from 55.1 to 60.4 (average 58.1) per cent of the total length.

Several trends in variation are apparent in the Illinois series. Southeastern Illinois specimens are usually more heavily spotted above, are shorter-legged, have fewer vomerine teeth, and have less prominent secondary sexual characters than salamanders from the Lower Mississippi Border counties. These trends in three samples are summarized in table 11. Data for single specimens from localities geographically intermediate have not been included in the table.

Habits.—In Illinois, the cave salamander is not restricted to caves. In fact, the two localities where the species is most abundant are cypress swamps, one near Forman in Johnson County and one at Pine Hills in Union County. Both of these areas are bordered by rock bluffs, however, and both contain swamps that are spring fed. Adults and transforming larvae are common under logs and leaves within the swamp well away from the rock outcrops. Cave salamanders are nocturnal, spending the day concealed under objects along stream margins, in

Table 11.—Geographic variation in Illinois *Eurycea lucifuga*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHEASTERN ILLINOIS (17)		UNION COUNTY (15)		MONROE COUNTY (7)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)...	30-62	.....	37-57	.....	49-60	.....
Total length (mm.).....	65-138	.....	79-141	.....	129-136	.....
Vomerine teeth.....	17-33	22.6	18-32	24.4	25-39	31.4
Toes of adpressed limbs...	-1½ - +1½	.....	-½ - +2	.....	-1½ - +2	.....
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Costal grooves 12.....	6		0		0	
Costal grooves 13.....	76		80		86	
Costal grooves 14.....	18		20		14	
Males with cirri.....	0		26.6		57.7	

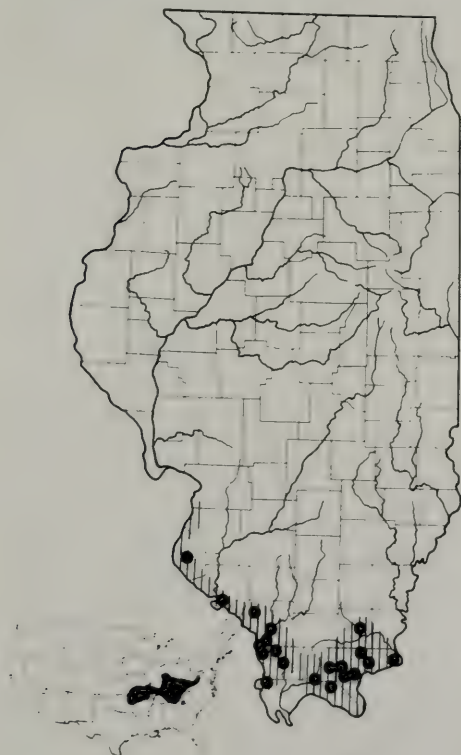


Fig. 38.—Distribution of *Eurycea lucifuga*. The hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

crevices in the rock outcrops, or in caves. At night a number of cave salamanders may be found on a single large boulder. They are quick and surprisingly difficult to pick up because of their slipperiness and alertness. *E. lucifuga* feeds chiefly upon arthropods.

Little is known of the life history of this salamander. Females with well-developed eggs have been taken in spring and in fall. The larvae, which are similar to other *Eurycea* larvae, overwinter one or more seasons. They transform throughout the warm months.

Illinois Distribution.—This species occurs in caves and springs throughout the Shawnee Hills division and in the Lower Mississippi Border counties north to at least Monroe County, fig. 38.

Hemidactylum Tschudi

The monotypic species of this predominantly northern genus is known only in extreme northeastern Illinois.

Hemidactylum scutatum (Schlegel) Four-Toed Salamander

Salamandra scutata Schlegel 1838:119 (type locality: Nashville, Tennessee).

Hemidactylum scutatum, Gebhard 1854:25.

Hemidactylum scutatum, Kennicott 1855:593.

Diagnosis.—A small, slender plethodontid salamander (largest Illinois specimen 95.5 mm. in total length), fig. 39; 4 toes on



Fig. 39.—An adult *Hemidactylium scutatum* from Ste. Genevieve County, Missouri. The groundcolor above is yellowish brown or reddish brown, below enamel white spotted with black.

each hind foot; tail with a basal constriction; a distinct median impressed line from base of tail to top of head, where it bifurcates; 12 to 14 costal grooves; groundcolor below white, with numerous black blotches.

Variation.—Bishop (1941) reported that males of this salamander are smaller and more slender and have slightly longer tails, more reddish brown above, and more prominently truncate snouts than females.

Blanchard & Blanchard (1931) have adequately described ontogenetic variation in this species and have prepared graphs to determine age groups. Young of the year are said to average 30 mm. long in females and 33 mm. in males by October. These juveniles differ from adults in the absence of basal tail constrictions and in their proportionately shorter tails. At the end of the second season, males average 50.6 mm. long and females 55.1 mm. The constriction at the base of the tail is then evident, and the tail is longer than the snout-vent length of the animal.

In the small series of Illinois specimens at hand, individuals range from 29.2 to 40.5 mm. in snout-vent length and 71.0 to 95.5 mm. in total length. Costal groove counts are 13 in seven specimens, 12 in four. Costal folds between the adpressed limbs range from $2\frac{1}{2}$ to $5\frac{1}{2}$. The dorsum is plain red-brown or yellow-brown, with indistinct darker spots. The venter varies from plain white to well spotted, with evenly distrib-



Fig. 40.—Distribution of *Hemidactylium scutatum*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States as currently known.

uted blotches. Most specimens are intermediate in ventral pattern, possessing black spots lateroventrally.

Habits.—The four-toed salamander is extremely rare in Illinois, and all the available specimens are quite old. The species is reportedly a bog animal, occurring under logs, bark, or sphagnum. Its food presumably consists of minute arthropods.

According to Bishop (1943) breeding occurs in late summer and fall, but oviposition does not take place until spring. Approximately 30 eggs in a cluster are laid near water in sphagnum or among roots of vegetation. The female remains with the eggs for the 1 to 2 months required for hatching. Metamorphosis occurs about 6 weeks after hatching.

Illinois Distribution.—The four-toed salamander is thus far known only in Lake and Cook counties, fig. 40, but may also occur in northwestern Illinois.

Plethodon Tschudi

This genus includes 15 species, most of which consist of two or more subspecies. Three species occur within Illinois.

Plethodon cinereus cinereus (Green) Red-Backed Salamander

Salamandra cinerea Green 1818:356 (type locality: New Jersey; revised to vicinity of Princeton by Schmidt 1953).

Plethodon erythronotus cinerea, H. Garman 1892:366-7.

Plethodon cinereus cinereus, Davis & Rice 1883a:26-7.

Plethodon cinereus, Shelford 1913:197, 243, 244, 256.

Plethodon cinereus erythronotus, Yarrow 1882a:154.

Plethodon erythronotus erythronota, H. Garman 1892:366-7.

Diagnosis.—A small, slender salamander (largest Illinois specimen 109 mm. in total length), fig. 41, with two color phases; lead-backed phase uniformly black or brown above; red-backed phase dark, with a mid-dorsal, straight-edged red band extending from the occiput well onto the tail; limbs small and weak, the toes of the adpressed limbs separated by 4 to 9 costal folds, usually more than 6; costal grooves usually 18 or 19, sometimes 17 or 20; tail of adult slightly longer than snout-vent length; secondary sexual characters poorly developed; ventral interhumeral area (in life) without orange suffusion.

Variation.—Specimens of the red-backed salamander are difficult to sex accurately by external characters, although females tend to be slightly larger and to have more vomerine teeth than males. The males, when they are sexually active, have nasolabial swellings and each has a shelf on the tip of the lower jaw.

Juveniles differ from adults in having relatively shorter tails, relatively larger heads



Fig. 41.—Adult *Plethodon cinereus cinereus* from Clark County, Illinois. The specimen at the left is the dark, unicolor phase; the specimen at the right, a red-backed example.

Table 12.—Geographic variation in Illinois *Plethodon cinereus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	VERMILION COUNTY (18)		CLARK COUNTY (18)		CRAWFORD COUNTY (27)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.).....	25-47	.....	28-51	.....	28-51	.....
Tail length as percentage of total length.....	45.2-55.1	51.9	45.0-55.0	51.8	44.0-54.8	50.0
Costal grooves.....	18-20	19.1	17-19	18.6	18-20	19.5
Separation of toes of adpressed limbs.....	6.0-9.0	7.9	5.5-9.0	7.1	7.5-10.0	8.4
Vomerine teeth.....	7-15	10.7	9-18	13.0	9-16	12.4

and limbs, and lower average numbers of vomerine teeth. Bishop (1941) noted that the red middorsal stripe continues to the tip of the tail in a juvenile, whereas it terminates somewhere in the distal third of the tail in an adult.

The red-backed and lead-backed phases of this salamander occur together in all localities where the species is known in the state. The red-backed phase predominates in Illinois collections, averaging 66 per cent, except in a sample from Crawford County, where only 2 per cent are red-backed and the remainder are dark. This sample has a somewhat higher average costal groove count than other samples and a greater average number of folds between toes of the adpressed limbs. It possesses an extraordinary range of variation in ventral pigmentation, some specimens having a uniform blue-black venter, others having the stippling more or less typical of *Plethodon cinereus cinereus*, and still others having a dark venter with coarse patches of white pigment. Although the Crawford County sample is aberrant in these respects and shows some approach to *P. richmondi* of the Appalachian Plateaus region, its characters widely overlap those of *P. c. cinereus*, to which it is here assigned.

The geographic variation illustrated by the Crawford County sample and two other collections of *P. cinereus* is summarized in table 12.

A population of red-backed salamanders occurring on the Mississippi River bluffs from Jackson to Alexander counties has been referred to *P. cinereus* by various authors, but a recent study of the relationships of this population reveals that, al-

though it shares with *cinereus* a straight-edged middorsal stripe, other characters indicate that it should be referred to *P. dorsalis*. It is accordingly discussed in more detail under that species.

Habits.—In the early spring, the small, slender red-backed salamanders are most frequently encountered under logs and rocks or within moist rotten stumps on hillsides. Later in the season, as the ground dries out, these salamanders retreat into the ground or move down the hillsides, where there is more moisture. When first uncovered they remain motionless, but when prodded they rush away to cover, each with looping movements of the tail and body. Captive specimens climb vertical surfaces with ease, as the moist body adheres firmly to almost any smooth surface. The food of the red-backed salamander consists of minute arthropods, annelids, and mollusks. Collembola are probably important dietary items.

Of this salamander, Bishop (1941) records that, in New York, spermatophores are deposited on leaves and sticks in late fall. The females receive the sperm packets, and after fertilization the eggs are laid in crevices, usually in rotten logs or under bark. Occasionally several females may be found within one rotten log, each guarding her suspended cluster of approximately half a dozen eggs. Hatching occurs in late summer. Each newly hatched larva is attached to the yolk of the egg for a period of a day or so, after which the gills disappear; the hatchling is a terrestrial salamander. The aquatic stage, characteristic of most amphibians, has been lost in species of *Plethodon*, and most of the brief larval period is spent within the egg.



Fig. 42.—Distribution of *Plethodon cinereus*. Hatching indicates the presumed range of the subspecies *cinereus* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

Illinois Distribution.—The red-backed salamander is known in Illinois only from the extreme eastern part, fig. 42. In north-eastern Illinois, it is inexplicably rare or perhaps extinct. It abounds in adjacent Indiana and in nearby Michigan.

Although undocumented by specimens, published records for the following localities are believed valid: COOK COUNTY: West Northfield (Yarrow 1882a); VERMILION COUNTY: Lake Vermilion (Peters 1946). (Records not plotted because of proximity to records based on museum specimens.)

***Plethodon dorsalis* Cope**
Zigzag Salamander

Plethodon cinereus dorsalis Cope 1889:138
(type locality: Louisville, Kentucky); Bishop 1943:236.

Plethodon dorsalis, Stejneger & Barbour 1917: 15.

Plethodon cinereus nec Green, Cagle 1942a: 176.

Diagnosis.—A small, slender, red-backed or uniformly dark salamander (largest Illinois specimen 114 mm. in total length), fig. 43, allied to *Plethodon cinereus*, but differing over most of its range in having a strongly lobulated (zigzag rather than straight-edged) red or yellow middorsal band, or a straight-edged middorsal stripe with the following combination of characters: 16 to 18 costal grooves; 3.5 to 7.5 costal folds between toe tips of adpressed limbs; tail length of adult usually less than snout-vent length; shoulder and interhumeral region pigmented with orange or red (in life); mental gland prominent in male; and a stouter body, the statement in Bishop (1943) that *P. cinereus* is less slender than *dorsalis* notwithstanding.

Variation.—Bishop (1943) noted that well-marked sexual dimorphism is lacking in this species. The specimens in our series, on the contrary, display marked sexual characters, the male differing from the female in having a conspicuous mental gland, nasolabial swellings, and a pair of free lips at the posterior end of the vent. The vent of the female is a simple slit.

Ontogenetic variation in this species is similar to that found in *P. cinereus*. The number of vomerine teeth shows less correlation with body size, but the number of costal folds between toes of the adpressed limbs and the body size are more directly correlated.

Rather marked geographic variation is exhibited by this species in Illinois. A population in the extreme southwestern part of the state (the Mississippi River bluffs of Alexander, Union, and Jackson counties) is atypical, inasmuch as it consists entirely of the red-backed phase and consists almost invariably of salamanders with straight-edged middorsal stripes. These salamanders, because of their pattern features, bear a remarkable superficial resemblance to the allied *P. cinereus*. A population in southeastern Illinois is typical *P. dorsalis* in structural and pattern features, most obviously in the zigzag stripe of the red-backed phase. The salient features of variation exhibited by a sample of typical *dorsalis* and by a sample of the Mississippi River bluffs salamanders are summarized in table 13.

Two specimens from Vermilion County and a small series from a locality between Anna and Jonesboro, Union County, appear to be typical *dorsalis*.

Individual variation among specimens of the typical population is manifested primarily in the representation of the two color phases and by the distinctness of the mid-



Fig. 43.—An adult *Plethodon dorsalis* from Pope County, Illinois. The groundcolor is dark brown or black; the middorsal stripe, when present at all, is red or yellow.

Table 13.—Variation in two samples of Illinois *Plethodon dorsalis*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHEASTERN ILLINOIS (65)		MISSISSIPPI RIVER BLUFFS (49)	
	Range	Mean	Range	Mean
Stripe width as percentage of body width.....	23-44	32.0	23-41	32.0
Costal grooves.....	16-19	17.4	16-18	17.0
Folds between adpressed limbs.....	3.5-8.0	5.5	2.0-7.0	5.4
Tail length as percentage of total length.....	42.5-51.5	46.8	42.5-51.5	47.6
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Red-backed.....	69		96	
Red-backed with zigzag stripe.....	98		15	

dorsal stripe. Unlike *P. cinereus*, this species includes occasional specimens intermediate between the two color phases, and the zigzag stripe can be discerned in some intermediates only by careful examination. Among specimens with the red or yellow stripe, the lobulations extend posteriorly for the entire body length in approximately one-third of the material at hand, but for at least half of the body length in the majority of the specimens. A specimen from Hardin County is anomalous, with the middorsal band straight-edged on one side and strongly angulated on the other.

Habits.—In the early spring, zigzag salamanders are extremely abundant under flat rocks on wooded hillsides. In habits they are similar to red-backed salamanders but they are perhaps more rigidly restricted to a rock habitat. During the summer and fall they are rarely found; presumably they retreat into caves or rock crevices.

The life history of *P. dorsalis* is probably similar to that of the related *P. cinereus*, although *dorsalis* probably lays its eggs in crevices of rock outcrops rather than in logs.

Illinois Distribution.—This species has been confused with *P. cinereus* because of the difficulty of describing adequately the rather slight differences between the two species and because each species has a unicolorous phase. Most of the early references to *P. dorsalis* in Illinois were based on presumptions that this species would be found eventually in eastern Illinois or were obvious misidentifications of *P. cinereus*. Prior to 1948 the only published record for *dorsalis* was almost certainly in error, as the record, based on specimens AMNH 23297-3301 and labeled Urbana, Illinois, has not been substantiated by additional collections. Moreover, suitable habitat for this species is completely lacking in the vicinity of Urbana. During the first season of field work for the study reported here, *dorsalis* was found to be common in southwestern Illinois, as various authors had predicted, and the species is now known in much of the Shawnee Hills region, as well as in eastern Vermilion County, fig. 44.

It is now apparent that *P. dorsalis* has long been collected in southwestern Illinois but, until recently, has been invariably misidentified as *P. cinereus*. The status of the Mississippi River bluff population is still



Fig. 44.—Distribution of *Plethodon dorsalis*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

uncertain. There is some possibility that it is a colony of hybrid origin, inasmuch as the population combines certain characters of *dorsalis* and Ozarkian *cinereus* and there are good zoogeographic reasons for assuming that a segment of Ozark *cinereus* may have been isolated on the Illinois side of the Mississippi River. However, except for its minute geographic range, there is equal justification for describing the population in southwestern Illinois as new. The hiatus between its range and that of typical *dorsalis*, fig. 44, seems to be real, suggesting that the population has attained reproductive isolation. Until more definite evidence becomes available, however, it seems advisable to recognize it as an aberrant colony of *P. dorsalis*.

It is regarded by some current students as consanguineous with the Ozarkian *Plethodon cinereus angusticlavius*, but I consider it distinct.



Fig. 45.—An adult *Plethodon glutinosus glutinosus* from Richland County, Illinois. The groundcolor is black; the dots are milky white.

***Plethodon glutinosus glutinosus* (Green)**
Slimy Salamander

Salamandra glutinosa Green 1818:357 (type locality: vicinity of Princeton, New Jersey).
Plethodon glutinosus, Yarrow 1882a:155.
Plethodon glutinosus glutinosus, Bishop 1943: 250.

Diagnosis.—A medium-sized terrestrial salamander (largest Illinois specimen 167

mm. in total length), fig. 45, black or blue-black above, with white flecks; usually frosted with white or silvery white on lower sides and uniformly black or black with occasional light flecks below; 14 to 15 costal grooves; usually 1 to 4 costal folds between toe tips of adpressed limbs; 12 to 22 vomerine teeth; tail of adult usually slightly longer than snout-vent length, and often lighter ventrally than belly.

Table 14.—Geographic variation in Illinois *Plethodon glutinosus glutinosus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	WABASH BORDER (15)		SOUTHERN DIVISION (17)		SHAWNEE HILLS (15)		RANDOLPH AND MONROE COUNTIES (15)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	48.5–76.0		49.0–68.2		57.0–71.2		44.8–72.0	
Total length (mm.)	107–167		100–143		114–163		123–156	
Tail length as percentage of total length	49.9–58.5	54.2	51.0–55.2	53.4	49.6–56.2	53.3	50.5–55.8	53.3
Combined vomerine tooth count	14–23	16.8	11–20	15.7	15–22	18.0	12–22	17.0
Folds between toes of adpressed limbs	½–4½	2.5	1–3½	2.2	2–3½	2.7	1–3½	2.3
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Costal grooves 14	80		24		0		20	
Costal grooves 15	20		76		100		80	
Lateral blotches	67		47		60		93	
Small spots	33		53		40		7	

Variation.—In this salamander, the male differs from the female in having a noticeable mental gland or a circular light spot that indicates the position of the gland. Many males have in addition prominent nasolabial swellings.

Young specimens, less than 40 mm. in length, possess proportionately larger heads, more prominent eyes, and shorter tails than adults. Specimens less than 70 mm. in total length often have a brownish cast and the skin under magnification appears closely punctate with white. Superimposed on the small round dots are occasional larger light flecks that are most pronounced on the sides. In the smallest specimens at hand the venters are dull gray; in half-grown specimens the venters are dark, and the chins and undersides of the tails are light; and in adults the undersides of the tails and feet are lighter than the chins and bellies.

Geographic variation within the state is seen in the tendency toward a relatively low costal groove count, long tail, and large maximum size in individuals from the Wabash Border counties (Clark and Vermilion), table 14.

Habits.—Slimy salamanders are usually found under logs or rocks, but at night and on rainy days they may be seen wandering abroad. They are quick and so slimy that they are difficult to pick up. The slime is sticky and hard to remove from the hands. During early spring these salamanders are abundant on wooded hillsides, but later in the season, as the ground dries out, they retreat to moist situations, such as the interior of rotten logs. Their food consists of arthropods and annelids.

The life history of this common species is poorly known. The 10 to 20 eggs laid by the female are said to be suspended by a slender stalk within rock crevices or rotten logs. The female remains with the eggs. The entire larval period is spent within the egg; at hatching the young salamanders are ready for a terrestrial existence.

Illinois Distribution.—The slimy salamander occurs in forested areas throughout the southern half of the state, fig. 46; it is sporadic in occurrence at the northern edge of its range and on extensive floodplains. At the periphery of the range in Illinois, the occurrence of the species is correlated with relatively mesic forest and rock outcrops. Numerous forest areas, apparently

suitable but without rock outcrops, in Coles County, for example, have been combed for this species without success, but wooded and rocky areas in adjacent Clark and Shelby counties have yielded slimy salamanders on almost every visit. Considerable field work in the lower Wabash River valley has not revealed this salamander there, even though the woods appear to be ideal plethodontid habitat. The absence of records for the Mississippi River counties north of St. Louis is inexplicable, inasmuch as no obvious break in habitat occurs in the St. Louis region.

The single published record for West Northfield, Cook County, in northern Illinois (Yarrow 1882a) has been justifiably deleted from the Cook County fauna by Schmidt & Necker (1935) on the basis of



Fig. 46.—Distribution of *Plethodon glutinosus*. Hatching indicates the presumed range of the subspecies *glutinosus* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

its remoteness from the continuous range of the species and the absence of additional collections of the slimy salamander. Yar-row's record was probably based on a mis-identified specimen of the superficially similar *Ambystoma laterale*.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: 5 mi. S Carbondale, near Murphysboro (Cagle 1942a); MADISON COUNTY: (Hurter 1911); ST. CLAIR COUNTY: (Hurter 1893).

Desmognathus Baird

This eastern genus includes nine species in the United States, some of which have several subspecies. One form occurs within Illinois.

Desmognathus fuscus conanti Rossman Dusky Salamander

Desmognathus fuscus conanti Rossman 1958: 158 (type locality: 2.1 mi. S Smithland, Livingston County, Kentucky).

Desmognathus fuscus fuscus nec Rafinesque, Davis & Rice 1883b:14.



Fig. 47.—Adult *Desmognathus fuscus conanti* from Pulaski County, Illinois. The ground-color ranges from yellow or light red-brown to dark brown; the markings are usually some shade of brown.

Desmognathus fuscus, Schmidt & Necker 1935: 60.

Desmognathus fusca fusca nec Rafinesque, Yarrow 1882a:159.

Desmognathus fusca, Davis & Rice 1883a:27.

Desmognathus nigra, Yarrow 1882a:160.

Desmognathus fusca auriculata nec Holbrook, H. Garman 1892:358-9.

Diagnosis.—A moderately stout, tan or brown salamander (largest Illinois specimen 100 mm. in total length), fig. 47, with a distinct light line from the eye to the angle of the jaws; tail triangular in cross section; nasolabial grooves present; 13 or 14 costal grooves; toes of adpressed limbs separated by more than 3 costal folds.

Variation.—Bishop (1941) reported that males of *Desmognathus fuscus fuscus* differ from females by their larger size, broader and longer heads, longer hind legs, presence of villi rather than folds on the cloacal lips, presence of mental glands, enlarged premaxillary teeth, and the usual absence of vomerine teeth. Sexual variation in *D. f. conanti* is presumably similar to that reported for *D. f. fuscus*.

No definite ontogenetic variation has been discerned in the Illinois series of *D. f. conanti*.

Eighteen specimens from Pulaski County vary as follows: snout-vent length 37 to 54 mm.; total length 63 to 100 mm.; costal groove counts 14 in 15 specimens, 13 in 1 specimen; separation of toes of adpressed limbs 2 to $4\frac{1}{2}$ (average 2.9) folds; vomerine teeth 0 to 1 in males, 9 to 16 (average 11.2) in females; groundcolor dark red-brown to light yellow. Some specimens are unicolorous; others have spotted, dashed, or vermiform markings.

A male and female from Union County display characters well within the range of variation of the Pulaski County series.

Habits.—Dusky salamanders occur in cold springs and are usually encountered by raking wet leaves or raising rocks at the margin of a spring or stream. These salamanders are alert, active, and extremely difficult to capture because of their quickness and slipperiness. Their food consists of arthropods, annelids, mollusks, and other salamanders.

Clusters of 10 to 20 eggs are deposited in nests near the water in both the spring and fall, according to Bishop (1941). The female remains with the eggs, which she

sometimes devours. Hatching occurs in 1 or 2 months, the length of time probably depending on temperature. The larvae make their way to water by wriggling. Transformation occurs in less than a year.

Illinois Distribution.—Despite the numerous literature reports of *D. fuscus* in Illinois, it appears that this species is restricted to a very few colonies in the extreme southern tip of the state, fig. 48. Although it is abundant in most of the eastern United States, the nearest valid record outside of Illinois is for extreme western Kentucky rather than for Indiana, suggesting that the species entered southern Illinois via the Mississippi River valley.

One specimen (USNM 3823), which has been reported from Illinois as *D. nigra* and assumed to be *D. fuscus* by many authors, is actually a specimen of *D. quadramaculata*

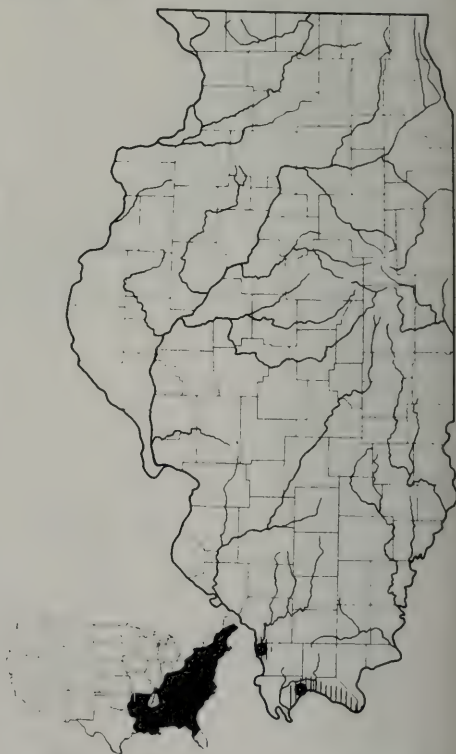


Fig. 48.—Distribution of *Desmognathus fuscus*. Hatching indicates the presumed range of the subspecies *conanti* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

and obviously has incorrect locality data. The specimens MCZ 2054 and 2056, labeled as from Normal, Illinois, are *D. fuscus*, but undoubtedly they are from some other state. The record of Hankinson (1915) for Coles County was questioned by Dunn (1926); almost certainly Hankinson confused *Desmognathus* with larval *Eurycea*. Yarrow (1882a) and other authors reported dusky salamanders from Mount Carmel, Wabash County, probably on the basis of Robert Ridgway's recollection of these salamanders. A series of *Desmognathus*, supposedly collected at Olney, Richland County, by Ridgway, is extant in the HJVC collection; since this series also includes specimens of California newts, it cannot be given serious consideration. The Union County specimens collected by "Black and Twomey" in 1935 and reported by P. W. Smith (1948) may have incorrect locality data, since repeated attempts to find the species in the same spring have been unsuccessful.

AMPHIUMIDAE

The family Amphiumidae consists of a single genus, which occurs in southeastern United States.

Amphiuma Garden

This genus contains one species, which consists of two subspecies. One of these may eventually be found to occur in extreme southern Illinois.

Amphiuma means tridactylum Cuvier Three-Toed Amphiuma

Amphiuma tridactylum Cuvier 1827:7, pl. 1, figs. 4-6, pl. 2 (type locality: New Orleans, Louisiana); Goodnight 1937:301; Cagle 1941:2; Baker 1947:12; Baker 1948:131; Brown 1950:25.

Amphiuma means tridactylum, Schmidt 1953:28.

Amphiuma means nec Garden, Weed 1923:50; Goodnight 1937:300, 301.

Diagnosis.—A large, eel-like, aquatic salamander without external gills and with 4 tiny legs, each leg bearing 3 toes.

Range.—This southern species has been found northward in the Mississippi River valley almost to Illinois. The authors cited above presumed that the species ranges into Illinois, but no specimens have been taken

within the state despite efforts of a number of collectors. The species is known in western Kentucky, only 25 air-line miles south of Cairo, Illinois (S. A. Minton, personal communication), and it is accordingly a possibility for the Cairo region.

PROTEIDAE

One genus of this family occurs in eastern North America.

Necturus Rafinesque

The genus contains four species, one of which is polytypic and is widely distributed in eastern North America. The nominate subspecies of the polytypic species inhabits Illinois.

Necturus maculosus maculosus (Rafinesque)

Mud Puppy Waterdog

Sirena maculosa Rafinesque 1818:41 (type locality: Ohio River).

Necturus maculosus, Eyleshymer 1906:126.

Necturus maculosus maculosus, Schmidt & Necker 1935:62.

Necturus lateralis, Kennicott 1855:593.

Menobranthus lateralis, Milner 1874:36, 62-3.

Necturus maculatus, Cope 1889:23-7.

Diagnosis.—A large aquatic salamander (largest Illinois specimen 344 mm. in total length), fig. 49, with permanent bushy gills and only 4 toes on each foot; tail length less than 38 per cent of total length; head flattened, swollen laterally behind the eyes; snout truncate; groundcolor slate to brownish gray, with scattered black blotches on back; sometimes uniformly dark above, occasionally with numerous black dots.

Variation.—Bishop (1941) noted that the male mud puppy differs from the female in having a longer vent, which has oblique wrinkles at the margin, a pair of papillae directed backward, and a curved groove bordering the posterior margin. The vent of the female is a simple slit. Five males and six females from Vermilion County display slight differences in relative tail length; tails of the males average 32.4 per cent of the total length and those of the females 34.1 per cent.

Two juveniles from Illinois, 40 and 42 mm. in length, are dark brown, with a pair



Fig. 49.—A subadult *Necturus maculosus maculosus* from Vermilion County, Illinois. The groundcolor ranges from light gray to dark olive; the spots on the body are brown or black; the gills, dark red.

of yellow dorsolateral stripes extending from the gills onto the tail. Bishop (1941) found that in New York the yearling salamanders average 55 mm. in length and have a middorsal yellow-brown stripe, bordered on each side by dull yellow bands. He found that 2-year-old specimens averaged 83 mm. in length and had longitudinal stripes that were dimmed by the appearance of rounded dark spots over the back; 3-year-old salamanders averaged 113 mm. in length and had stripes that were dimmer; and 4-year-old specimens averaged 148 mm. in length and had essentially the pattern of adults.

No geographic variation has been noted in the Illinois specimens of *Necturus maculosus*. Individual variation, especially in color and pattern, is pronounced; in a fair-sized series, specimens may be present resembling many of the recognized species of the genus, at least in details of pattern. Despite the variability of pattern, the Illinois specimens almost certainly belong to a single population.

The largest Illinois series of *N. maculosus* available consists of six males and five females from Vermilion County. Total lengths range from 208 to 343 mm. and the tail length comprises 30.2 to 37.3 per cent of the total length. Vomeropalatine teeth vary in number from 24 to 35 (average 31.2). Costal grooves are 15 or 16, and the toes of the adpressed limbs are separated by 6.0 to 8.5 costal folds (average 7.4). All 11 specimens are distinctly spotted above. Three specimens have a narrow, midventral, light stripe; three have venters entirely light; and five have a sharply defined light

stripe that is about half the width of the venter.

Seven specimens from western Champaign and Piatt counties are 235 to 344 mm. in length and vary as follows: tail length 31.3 to 35.6 (average 33.4) per cent of total length; costal grooves 15 to 17; toes of adpressed limbs separated by 6.0 to 9.5 (average 7.5) folds; vomeropalatine teeth 35 to 44 (average 40.1). Four of the seven are distinctly spotted above, and three are dark, two having the many black dots supposedly characteristic of the northern *N. m. stictus*. The venter color variation is similar to that in the Vermilion County series.

Single specimens at hand from localities in other parts of the state are, for the most part, well within the range of variation of the above series. A specimen (INHS 1002) from Rock Island County is almost identical with a Wisconsin specimen of *N. m. stictus*. A specimen (INHS 1003) from Massac County is much discolored but noteworthy because of its extremely squat body. An adult (INHS 8041) from 3 mi. NE Fairmount, Vermilion County, is an albino.

Habits.—Mud puppies or waterdogs occur in lakes, lagoons, rivers, and large creeks. They are frequently caught on hook and line by fishermen near ideal habitats, such as piles of driftwood that accumulate around bridge supports in moderate-sized rivers. Active throughout the year, they probably remain in deep water during the day. They are ugly, excessively slimy, and, although harmless, they are unpleasant creatures to handle. Their food consists of various fishes, arthropods, annelids, and mollusks.

Bishop (1941) records that pairing of males and females occurs in the fall but that oviposition does not take place until late spring. A gravid female lays approximately 100 eggs, usually on the underside of a submerged rock or log. Each egg is 5 to 6 mm. in diameter and suspended in a jelly-like sac. The eggs require about 2 months to hatch. The young are described briefly in the paragraph describing ontogenetic variation.

Illinois Distribution.—*Necturus* is statewide in distribution and probably abundant in suitable streams in every Illinois county, fig. 50, but it is difficult to collect by usual collecting methods. The accompanying map reflects the parts of Illinois where the most intensive collecting has been done, rather than the actual abundance of the species. Collections have recently been augmented by specimens obtained with the aid of electric

shocking equipment that aquatic biologists are now using.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COLES COUNTY: Cooks Mill (Hankinson 1917); COOK COUNTY: Evanston (Milner 1874); Wilmette (Necker 1939c); JACKSON COUNTY: Big Muddy River (Cagle 1942a); KANE COUNTY: Carpentersville (Schmidt & Necker 1935); LEE COUNTY: Sublette (Pope 1944b); MADISON COUNTY: (Hurter 1893); MARSHALL COUNTY: Henry (H. Garman 1892); OGLE COUNTY: Oregon (H. Garman 1892); PEORIA COUNTY: Peoria (H. Garman 1892); ROCK ISLAND COUNTY: Moline (Howard 1951); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WILL COUNTY: Joliet (Howard 1951); WILLIAMSON COUNTY: Crab Orchard Creek (Cagle 1942a).

SIRENIDAE

This family includes two genera, both found in eastern North America.

Siren Linnaeus

The genus *Siren* contains one monotypic and one polytypic species. A western subspecies of the latter occurs in Illinois.

Siren intermedia nettingi Goin Western Lesser Siren

Siren intermedia nettingi Goin 1942:211-7
(type locality: Imboden, Lawrence County, Arkansas).

Siren lacertina nec Linnaeus, Cope 1870:394.
Siren intermedia, Noble & Marshall 1932:2.

Diagnosis.—A large, eel-like salamander (largest Illinois specimen 457 mm. in total length), fig. 51, with 4 toes on each front foot, and no hind legs; 3 pairs of gills; body brown, black, dark olive, or bluish gray above, with or without small black spots; venter lighter than dorsum; margins of jaws with horny sheaths; 34 to 37 costal grooves, usually 34 or 35; venter and sides often marked with light flecks.

Variation.—Males of this species exceed females in size. I am unable to determine the sex of the specimens in our series by any external characters.



Fig. 50.—Distribution of *Necturus maculosus*. The subspecies *maculosus* occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.



Fig. 51.—An adult *Siren intermedia nettingi* from Pope County, Illinois. The color ranges from very dark brown to blue-black.

In a series of eight specimens from Pine Hills, Union County, two are larvae. The smaller larva, 19 mm. from snout to vent and 24 mm. in total length, is boldly marked above with a light (red in life) band that extends from the gill tufts on one side around the snout to the gills on the other side of the head. This band is broadest on the edge of the truncate snout. A pair of interorbital dashes, a transverse band across the occiput, and a middorsal stripe that extends from the gill region to the tip of the tail also are red in life. The larger larva, 44 mm. from snout to vent and 58 mm. in

Table 15.—Geographic variation in Illinois *Siren intermedia nettingi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (12)	MACOUPIN AND ST. CLAIR COUNTIES (4)	FULTON AND MASON COUNTIES (2)	CRAWFORD COUNTY (1)
	Range	Range	Range	Range
Snout-vent length (mm.).....	69-254	109-290	133-312	268
Total length (mm.).....	91-381	152-418	196-457	380
Tail length as percentage of total length.....	19.4-35.7	28.2-32.3	31.7	29.5
	PER CENT OF SPECIMENS	PER CENT OF SPECIMENS	PER CENT OF SPECIMENS	PER CENT OF SPECIMENS
Costal grooves 34.....	60	0	0	100
Costal grooves 35.....	40	100	100	0

total length, differs in lacking the inter-orbital and occipital bars. The dorsal fin extends well forward of the anus in both larvae, whereas in adults the fin originates just behind a point opposite the anus. The tail length of the larvae comprises, respectively, 20.8 and 24.2 per cent of the total length. Subadults less than 250 mm. in total length have nail-like cornifications on the toe tips. In large adults the toes have blunt, horny tips or no cornification at all.

No definite trends in geographic variation within Illinois have been discerned for the western lesser siren. A specimen from Mason County (INHS 6553) with a total length of 457 mm. appears to be the largest recorded for this salamander. There is considerable individual variation in the order of toe length, in color, and in distinctness of markings. Other variation for four small samples is to be found in table 15.

Habits.—The western lesser siren, which is permanently aquatic, frequents swamps, ditches, and sloughs. Captured individuals squirm violently and they are difficult to hold because of their slipperiness. Cagle & Smith (1939) found, in a culvert in southern Illinois, an aggregation of 138 individuals that appeared to be hibernating. There is evidence, however, that this salamander usually is active throughout the winter. Its food consists principally of arthropods, mollusks, and worms.

Bishop (1941) noted that the several hundred eggs, laid in early spring by the female of this salamander, are deposited in hollows in the mud bottom of a pond.

The eggs average about 3 mm. in diameter. Details are lacking regarding incubation time and larval development. A larva taken May 15 was less than 30 mm. in total length. This specimen was kept in a cattle watering trough until July 1. During this time it metamorphosed and attained a total length of 111 mm., having increased its length approximately fourfold in 6 weeks.

Illinois Distribution.—The exact range of *Siren* in Illinois can be only guessed. Probably the population has been reduced in historic times to narrow fingers of flood-plain swamp that margin the medium-sized and large rivers of the state, fig. 52. In the Illinois River valley the species occurs north to Peoria County. The absence of records for counties in the upper Mississippi River valley is unaccountable, since the extensive



Fig. 52.—Distribution of *Siren intermedia*. Hatching indicates the presumed range of the subspecies *nettingi*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

river bottoms seem to offer ideal habitat. The statement that the species occurs in northern Illinois (Davis & Rice 1883a, 1883b) was based on a specimen in the Northwestern University collection. No specific locality was given, and the specimen has disappeared. The former occurrence of *Siren* in northeastern Illinois is possible, however, in view of records for Porter County, Indiana (Pope 1944b).

This salamander is common in the southern fourth of Illinois, but it is difficult to collect by conventional techniques. If special effort is made, it can be taken in numbers. Many specimens can be secured in the Pine Hills swamp with a minnow seine. I have heard reports of animals fitting the description of *Siren* from Effingham, Fayette, and Jasper counties, in addition to the localities plotted on the map, fig. 52.

Published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CASS COUNTY: Beardstown (Weed 1923); MADISON COUNTY: Alton (Cope 1875); MONROE COUNTY: (Hurter 1911); PERRY COUNTY: 5 mi. E Du Quoin (Goin 1942); RANDOLPH COUNTY: (Hurter 1911); ST. CLAIR COUNTY: (Hurter 1911); UNION COUNTY: 5 mi. NE Jonesboro (Goin 1942); Union County State Forest (Cagle 1942a); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WILLIAMSON COUNTY: 1 mi. NE Herrin (Cagle & Smith 1939); Johnston City, Marion (Cockrum 1941).

Order SALIENTIA

Frogs and Toads

Twenty-one species and subspecies of frogs, treefrogs, and toads occur in Illinois.

Members of the order Salientia may be divided into three rather artificial groups: the true frogs, the toads, and the treefrogs. The true frogs, in general, are terrestrial, but they are forced to remain near water because of their rapid rate of dehydration. The toads are more resistant to desiccation and may occur far away from ponds and streams. The treefrogs also are fairly resistant to desiccation and they are usually

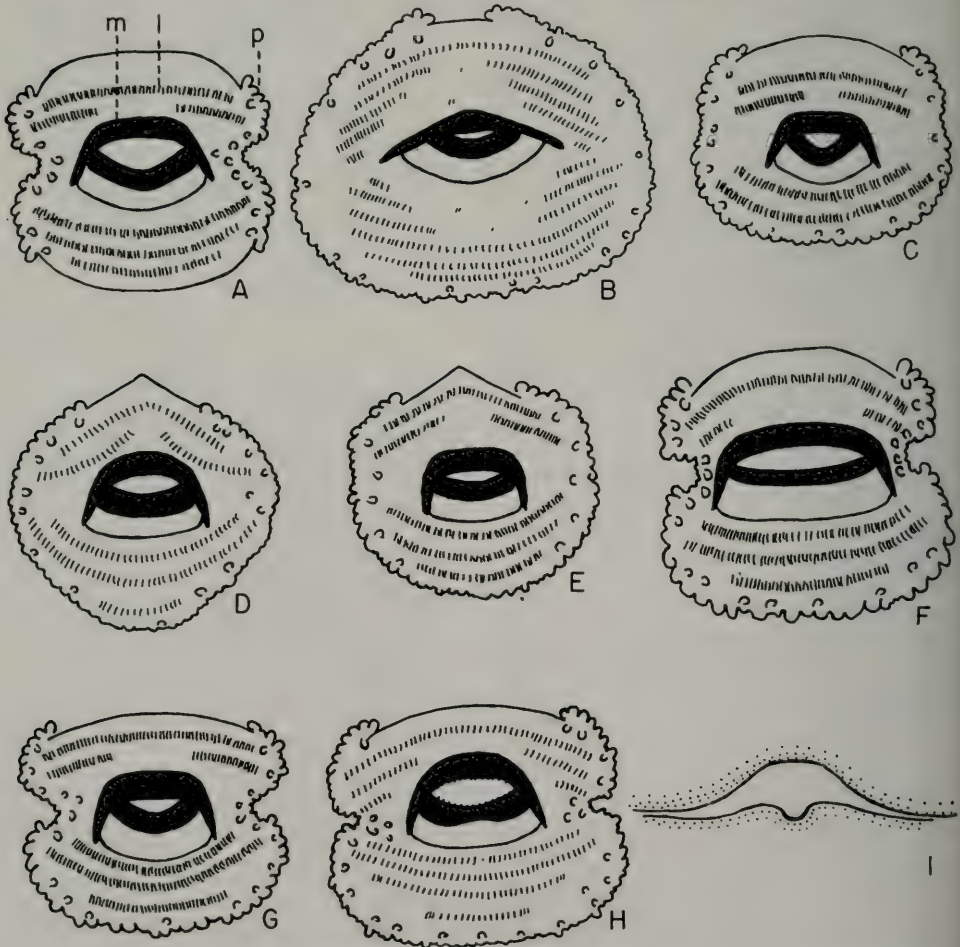


Fig. 53.—Mouthparts of some Illinois tadpoles (A-I): A, *Bufo americanus americanus*; B, *Scaphiopus holbrooki*; C, *Acris crepitans blanchardi*; D, *Pseudacris streckeri illinoensis*; E, *Hyla versicolor versicolor*; F, *Rana clamitans melanota*; G, *Rana pipiens sphenoccephala*; H, *Rana sylvatica sylvatica*; I, *Gastrophryne carolinensis carolinensis*; l, labial teeth; m, mandible; p, papillary fringe.

arboreal in habits. Frogs and toads are primarily nocturnal, although they may be encountered occasionally during the day. In size they range from the inch-long cricket frog to the 8-inch bullfrog. All Illinois salientians are predatory and partially or exclusively insectivorous. Most frogs and toads are alert and quick in their movements. Their ability to leap, their habit of concealing themselves, and their protective coloration aid them in escaping predators.

Typically, the salientian life history begins anew each spring with migration to water. The males arrive first and utter their characteristic mating calls; the females follow in a day or so, and the clasping process or amplexus occurs. The males fertilize the eggs as they are laid by the females; after fertilization the eggs develop jelly-like envelopes. The eggs may be single, in strings, or in packets. They may be floating masses or they may be attached to objects on the bottom of a pond or stream. Hatching occurs in a few days, and the tadpoles or larvae begin feeding on algae almost immediately. The tadpole, which is limbless, has modified mouthparts consisting of a horny beak and rows of labial teeth. The arrangement of the mouthparts is distinctive for all genera and for some species, fig. 53. When the tadpole is a few weeks old, limb buds appear. The hind legs develop a few days earlier than the front legs. As the limbed tadpole grows, it spends more and more time at the edge of the water or at the surface. Gradually the tail is resorbed, and certain internal changes take place. The newly transformed froglet, recognizable by the temporary tail stub, has undergone important changes in the respiratory, circulatory, digestive, and skeletal systems, and by the end of summer the animal has acquired adult features, fig. 54.

Variations from the typical life cycle among the Illinois species consist of differences in length of time required for attaining adulthood, differences in breeding sites, and differences in breeding seasons. All of the Illinois species have an aquatic larval stage.

Five of the 21 species and subspecies known in Illinois have ranges centering to the south of the state. These are *Scaphiopus holbrookii*, *Hyla avivoca*, *H. cinerea*, *Rana pipiens sphenocephala*, and *Gastrophryne carolinensis*. The last species is of special

interest, inasmuch as the Illinois population seems to be a relict rather than a peripheral colony. Farther south the species is both generally distributed and abundant.

Two Illinois frogs have ranges that center to the north of Illinois and that extend southward approximately to the central part of the state. These are *Rana pipiens pipiens* and *Rana sylvatica cantabrigensis*.

Six essentially eastern frogs enter Illinois from the east or southeast. These are *Pseudacris triseriata feriarum*, *Hyla crucifer crucifer*, *H. versicolor versicolor*, *Rana clamitans melanota*, *R. palustris*, and *R. sylvatica sylvatica*.

Four predominantly western frogs have ranges that extend into or beyond Illinois. These are *Bufo americanus charlesmithi*, *Pseudacris triseriata triseriata*, *P. streckeri illinoensis*, and *Rana areolata*. *Pseudacris s. illinoensis* is deserving of special note because the Illinois population is a relict with a hiatus of about 300 miles between it and the nearest population of *P. s. streckeri*.

Four species are wide-ranging and cannot be classified readily. These are *Bufo americanus americanus*, *B. woodhousei fowleri*, *Acris crepitans*, and *Rana catesbeiana*.

Key to the Order Salientia

(Frogs and Toads)

1. Horny cutting tubercles on heel of each foot, fig. 55 2
No horny cutting tubercles on heel of each foot 5
2. One elongate, spadelike cutting tubercle on each heel, fig. 55; parotoid glands round and inconspicuous; eye pupils vertically elliptical (Pelobatidae)
..... *Scaphiopus holbrookii*
Upper and lower horny tubercles on each heel, fig. 56; parotoid glands prominent and elongate; eye pupils horizontally elliptical (Bufonidae) 3
3. Venter plain or with a necklace of small spots across breast; maximum snout-vent length 75 mm. 4
Venter completely spotted or mottled with dark; maximum snout-vent length 95 mm. *Bufo americanus americanus*
4. Dorsal dark spots on body small, each usually including a single tubercle; tibial warts distinctly larger than femoral warts ... *Bufo americanus charlesmithi*
Dorsal dark spots on body large, each usually including many tubercles; tibial warts no larger than femoral warts *Bufo woodhousei fowleri*
5. Transverse fold of skin behind head; head less than one-fourth snout-vent length;

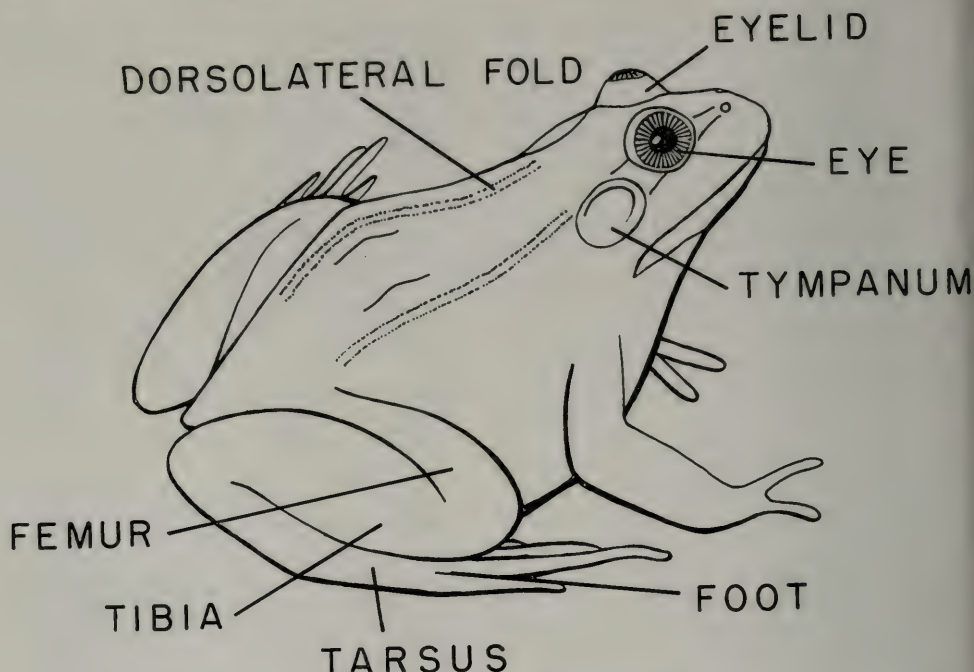
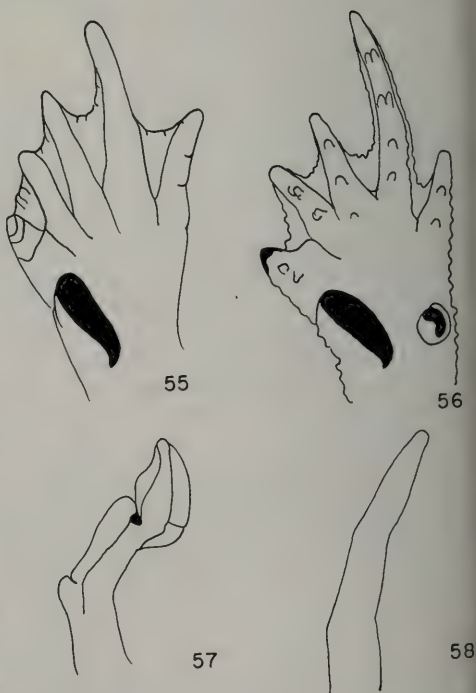


Fig. 54.—Lateral view of a frog.

- tympanum absent (Microhylidae)
- Gastrophryne carolinensis carolinensis*
No fold of skin behind head; head approximately one-third the snout-vent length; tympanum present 6
6. Terminal toe pads and intercalary cartilages present, fig. 57 (Hylidae) 7
- Terminal toe pads and intercalary cartilages absent, fig. 58 (Ranidae) 14
7. Toe pads scarcely wider than penultimate joints; snout-vent length less than 35 mm. 8
- Toe pads distinctly wider than penultimate joints; maximum snout-vent length 70 mm. 11
8. Toes fully webbed; back with numerous warts *Acris crepitans blanchardi*
Toes unwebbed, or web restricted to a flange on side of each digit; back smooth to granular 9
9. Lateral dark stripe arising on snout, passing through each eye to shoulder; sub-orbital dark spot; body short and squat *Pseudacris streckeri illinoensis*
Lateral dark stripe passing through each eye beyond shoulder; light, straight-edged maxillary stripe; no suborbital spot; body flattened and elongate 10
10. Tibia 47 per cent or more of snout-vent length; dorsal pattern weak; longitudinal stripes, if present, each usually less than one-half width of interspace *Pseudacris triseriata feriarum*
Tibia 46 per cent or less of snout-vent length; dorsal pattern usually of distinct longitudinal stripes, each stripe as wide

Figs. 55-58.—Characteristics of frogs: 55, foot of *Scaphiopus*; 56, foot of *Bufo*; 57, digit of *Hyla*, showing intercalary cartilage and terminal pad; 58, digit of *Rana*.

- as the space between stripes
Pseudacris triseriata triseriata
11. Groundcolor tan or pink, with a distinct dark X-mark on the back; undersides pink or yellow. *Hyla crucifer crucifer*
 No X-mark on back; dorsum unmarked or marked with blotches; venter gray or white 12
 12. Rear of femora mottled; suborbital light spot present; back variable in color, usually with a star-shaped dark blotch 13
 Rear of femora unmarked; no suborbital light spot; back green, without a star-shaped blotch. *Hyla cinerea*
 13. Rear of femora green, with dark reticulations; snout-vent length under 50 mm. *Hyla avivoca avivoca*
 Rear of femora orange or yellow, with dark reticulations; maximum snout-vent length 60 mm. *Hyla versicolor versicolor*
 14. A pair of dorsolateral folds extending down back, fig. 54; tympanic fold inconspicuous 15
 Dorsolateral folds absent; tympanic fold well developed. *Rana catesbeiana*
 15. Dorsolateral folds terminating just beyond mid-back, fig. 54 16
 Dorsolateral folds extending length of back 17
 16. Venter heavily reticulate with black; maximum snout-vent length 70 mm.; upper jaw of male olive, throat dusky. *Rana clamitans clamitans* × *melanota*
 Venter usually not heavily blotched or reticulate; maximum snout-vent length 95 mm.; upper jaw of male bright green, throat chrome yellow. *Rana clamitans melanota*
 17. No dark mask on side of head; dorsum with distinct spots 18
 Dark mask passing through eye and tympanum; dorsal pattern plain or dashed, but without distinct spots. 21
 18. Jaws mottled; dorsal spots closely crowded; groundcolor milky white and visible only as tracery around dorsal spots; maximum snout-vent length 110 mm. *Rana arcolata circulosa*
 Jaws without mottling; dorsal spots not closely crowded; maximum snout-vent length 100 mm. 19
 19. Dorsal spots square or rectangular, regularly arranged in a double row between dorsolateral folds; concealed surfaces of legs and venter yellow. *Rana palustris*
 Dorsal spots irregular in size and arrangement; concealed surfaces of legs and venter white 20
 20. Dorsal spots averaging larger than eye, usually distinctly light margined; snout usually with dark dorsal spot; breeding males with internal vocal sacs; ground-color green, tan, or brown *Rana pipiens pipiens*
 Dorsal spots averaging smaller than eye, not distinctly light margined; snout usually without spot; breeding males

with external vocal sacs; groundcolor tan, brown, or gray-green

21. Skin between dorsolateral folds usually smooth and unmarked; tibia usually more than 55 per cent of snout-vent length; maximum snout-vent length 60 mm. *Rana sylvatica sylvatica*
 Skin between dorsolateral folds often with secondary dorsal folds or with light or dark longitudinal markings; tibia usually less than 55 per cent of snout-vent length; maximum snout-vent length 50 mm. *Rana sylvatica cantabrigensis*

PELOBATIDAE

This family is regarded by some authors as having one genus in North America and by others as including two genera.

Scaphiopus Holbrook

Two or six species in the United States and Canada are included in the genus *Scaphiopus*, the number depending on the taxonomic viewpoints of various authors. One species, which belongs to typical *Scaphiopus*, is found in southern Illinois.

Scaphiopus holbrookii (Harlan)

Eastern Spadefoot

Rana holbrookii Harlan 1835:105 (type locality: South Carolina; revised to Charleston by Schmidt 1953).

Scaphiopus holbrookii holbrookii, Elder 1945: 122.

Scaphiopus holbrookii, P. W. Smith 1948:2.

Scaphiopus holbrookii, Burger, Smith, & Smith 1949:130.

Scaphiopus holbrookii holbrookii, Schmidt 1953: 58.

Diagnosis.—A medium-sized toad (largest Illinois specimen 59 mm. from snout to vent), fig. 59, lacking cranial crests and tubercles on the soles of the feet; vomerine teeth present; an elongate, dark-edged, horny spade on heel of each foot; vertically elliptical pupils; paired pectoral glands; yellow-gray and brown mottled groundcolor, with a pair of crescentic light bars extending from eyes to middle of back; tubercles on dorsum red tipped; chin and venter unspotted.

Variation.—In this species, the male differs from the female in having stouter fingers and black horny deposits on the upper surfaces of the first and second fingers. During the breeding season males have conspicuous subgular vocal pouches.



Fig. 59.—Adult *Scaphiopus holbrooki* from Alexander County, Illinois. The predominant color is dark brown; the crescentic dorsal markings are grayish yellow or bronzy; many of the warts are tipped with red spines.

Twenty specimens at hand fall into four size groups: 4 center about 26.5 mm.; 4 center about 30 mm.; 2 are about 45 mm.; and 10 range from 54 to 59 mm. from snout to vent. A female with a body length of 45 mm. contains eggs. The young toads differ from adults chiefly in their proportionately larger heads and greater wartiness. Specimens under 45 mm. have spines tipping almost all the body warts, whereas larger toads have spines that usually are restricted to warts on the head and interparotoid regions. Juveniles have poorly defined tympanums, and their dorsal tubercles are so arranged as to form two interparotoid ridges.

Head length in the 20 specimens comprises 33.9 to 38.5 per cent of the snout-vent length; head width 38.4 to 44.0 per cent; and tibia length 34.3 to 37.7 per cent. Adults vary in smoothness of skin, some large individuals being completely smooth in the mid-back region. The color varies from brown to black, with yellow-gray to dirty yellow markings.

Habits.—The spadefoot is subterranean and is usually found only in the breeding ponds. Most of our specimens have been obtained by following farmers' plows or raising logs. Toads of this species can quickly bury themselves, rear end first, by scooping away soil with the spades on their heels. Their food consists of arthropods and annelids.

Breeding of the spadefoot has been observed in May and August in southern Illinois. A specimen plowed up in June con-



Fig. 60.—Distribution of *Scaphiopus holbrooki*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle represents a published record believed to be valid. The lower map depicts the total range of the species in the United States.

tained well-developed eggs. Apparently breeding may occur any time between March and September, the time depending on the distribution of the heavy summer rains. Moderate rains do not provide sufficient stimulus for breeding. The mating call is a nasal grunt, uttered frenziedly, and can be heard almost half a mile away. Eggs are laid in short, irregular strings that are attached to vegetation in temporary pools or flooded fields. Hatching reportedly requires only 1 or 2 days, and the tadpoles may transform in 2 or 3 weeks. The broad, short-tailed tadpole has distinctive mouthparts, fig. 53.

Illinois Distribution.—The species is known in Illinois only in the southern tip of the state, fig. 60. Although this species occurs farther north on the Atlantic Coast, the nearest records outside Illinois are in Kentucky rather than Indiana, suggesting that the species entered southern Illinois via the Mississippi River valley.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: JACKSON COUNTY: Makanda (P. W. Smith 1948).

BUFONIDAE

Only one genus of the family Bufonidae is represented in the United States and Canada.

Bufo Laurenti

This world-wide genus contains 15 species in the United States and Canada, most of which consist of several subspecies. Two species occur in Illinois.

Bufo americanus Holbrook

Many authors prefer to regard *Bufo americanus* and the southern toad, *B. terrestris*, as conspecific and to recognize four subspecies of *terrestris*. For the most part, the ranges of the two toads are widely separated; Neill (1949b) has shown that where they are in contact they maintain their specific identities. I am in accord with Neill in believing that the two are best considered distinct species. *B. americanus*, as here defined, consists of three subspecies, a well-

marked Canadian race and two named races in the United States that are poorly defined morphologically and geographically.

Two populations of *B. americanus* occur in Illinois. A small, rather plain, woodland animal occurs sporadically in the southern half of the state; and a large, well-spotted, prairie form is abundant in the northern half. It is uncertain if either of the Illinois toads is the *B. americanus* of Holbrook, as a cursory examination of material from scattered localities in the eastern United States reveals that eastern toads are intermediate between the two Illinois forms in most characters.

The dwarf race in southern Illinois is provisionally referred to *B. a. charlesmithi*, because the paratypes I have examined are similar to the southern Illinois form, although appreciably smaller at sexual maturity. The large form of northern Illinois is provisionally, and reluctantly, referred to *B. a. americanus*, pending a complete reinvestigation of the *americanus* complex.

Bufo americanus americanus Holbrook American Toad

Bufo americanus Holbrook 1836:75, pl. 2 (type locality: Maine through all the Atlantic States; revised to vicinity of Philadelphia, Pennsylvania, by Schmidt 1953); Kennicott 1855:592.

Bufo lentiginosus americanus, Yarrow 1882a:166 (part).

Bufo americanus americanus, Schmidt & Necker 1935:64.

Bufo terrestris americanus, P. Smith 1947:30.

Bufo americana, Grassley 1923:130.

Bufo lentiginosus, Shelford 1913:187, 296.

Bufo fowleri nec Hinckley, Nichols 1937:18-9.

Bufo woodhousii fowleri nec Hinckley, Stille & Edgren 1948:197 (part).

Diagnosis.—A large toad (largest Illinois specimen 90 mm. from snout to vent), fig. 61, with conspicuous, elongate, parotoid glands and strongly developed cranial crests; venter dark spotted or mottled; tubercles on dorsal surface of tibia prominently enlarged; dark dorsal spots including more than one wart in about 50 per cent of individuals; head length usually less than 30 per cent of snout-vent length; parotoid gland length usually less than 21 per cent of snout-vent length.

Variation.—The male of the American toad differs from the female in being of smaller size and in having stouter first and

second fingers, horny deposits on these digits, and vocal pouches.

Juveniles differ from adults chiefly in having poorly developed cranial crests and inconspicuous tympanums. In details of pattern and proportions, no marked differences are apparent between subadults and adults. Newly transformed toads, however, are black and have light tubercles.

The most pronounced geographic variation is found in samples from Coles County and Adams and Hancock counties, near the southern edge of the range. Specimens in these samples are intermediate in size between the prairie form and the dwarf form. They approach the dwarf race in their pro-

portionate head length, relative parotoid length, and reduced ventral patterns. Other samples from the northern half of Illinois are rather homogeneous. The variation is summarized in table 16.

Habits.—The original habitat of the American toad is problematical since the species is best known in gardens, orchards, and lawns. Individuals are encountered both in woods and in fields. The species has been presumed (P. W. Smith 1947) to be essentially a prairie animal, since in eastern Illinois the range terminates abruptly at the Shelbyville Moraine. On a spring night these toads can be heard singing in almost every flooded field north of the moraine.



Fig. 61.—Dorsal and ventral views of a subadult *Bufo americanus americanus* (left) from La Salle County, Illinois, and an adult *Bufo americanus charlesmithi* (right) from Pope County, Illinois. The dorsal groundcolor of both subspecies ranges from dark brownish black to olive and even to rusty red. The red color is particularly common among males of *B. a. charlesmithi*.

During the day American toads hide in shrubbery or bury themselves in the soil, coming forth at dusk to feed on insects and worms.

The peak of the breeding season is mid-April. The call is a sustained, high, musical trill and can be heard during the day as well

as at night. The female lays several thousand eggs in long strings, and these strands may extend for several feet along the bottom of a pond or ditch. Each jelly string commonly contains double or sometimes triple rows of eggs, the individual eggs ranging from 1.2 to 1.4 mm. in diameter. Hatching occurs in approximately a week. The small black tadpoles, easily recognized as toad larvae, fig. 53, are almost identical in all the Illinois species of *Bufo*. Metamorphosis occurs in early June.

Heavy rain late in the season may stimulate singing by small, newly matured males.

Table 16.—Geographic variation in four samples of sexually mature Illinois *Bufo americanus americanus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME NORTHERN ILLINOIS (11)		CHAMPAIGN- SANGAMON COUNTIES (17)		COLES COUNTY (12)		ADAMS- HANCOCK COUNTIES (7)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
nout-vent length (mm.).....	55.2-76.2		60.8-90.0		55.2-74.8		47.0-67.0	
Head length as per- centage of body length.....	26.8-30.9	28.6	26.7-30.2	28.6	26.4-32.9	29.2	27.6-31.2	29.9
snout length as percentage of body length.....	17.5-22.8	19.4	15.6-21.5	19.0	16.6-23.4	20.4	18.8-23.8	21.4
Ventral pattern*....	3-5	3.9	3-5	4.1	2-5	3.0	2-4	3.2
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
One wart per dorsal spot.....	64		35		58		100	

*Ventral pattern indicated by index number. The index numbers have been assigned as follows: venter immaculate with a single pectoral spot, 1; a few scattered spots on the breast region, 2; a zone of dark spots across the breast, 3; entire venter spotted, 4; venter predominantly dark, 5.

at night. The female lays several thousand eggs in long strings, and these strands may extend for several feet along the bottom of a pond or ditch. Each jelly string commonly contains double or sometimes triple rows of eggs, the individual eggs ranging from 1.2 to 1.4 mm. in diameter. Hatching occurs in approximately a week. The small black tadpoles, easily recognized as toad larvae, fig. 53, are almost identical in all the Illinois species of *Bufo*. Metamorphosis occurs in early June.

Heavy rain late in the season may stimulate singing by small, newly matured males.

Illinois Distribution.—With the exception of the sand areas, where *Bufo woodhousei fowleri* predominates, *B. a. americanus* is the common toad of the northern half of Illinois, fig. 62. In much of the black oil prairie it is the only toad. Although this form is less conspicuous in northern Illinois than *fowleri* appears to be in the south-

ern half of the state, *americanus* is quite general in its occurrence. In spring breeding aggregations are surprisingly large even in some areas where toads are seldom seen at other seasons.

Nichols' (1937) study of the larval mouthparts of *B. w. fowleri* undoubtedly refers to *B. a. americanus*, since both breeding dates and locality preclude the possibility of his specimens being *fowleri*. Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Calumet City (Schmidt & Necker 1935); Evanston, Morton Grove (Necker 1939c); West Pullman (Hubbs 1918); Wilmette (Necker 1939c); Winnetka (Hubbs 1918); Wolf Lake (Schmidt & Necker 1935); DU PAGE COUNTY: Downers Grove, Glen Ellyn, Naperville (Schmidt & Necker 1935); KANE COUNTY: Batavia, West Dundee (Stille & Edgren 1948); LAKE COUNTY: Fox Lake, Half Day (Schmidt & Necker 1935); Waukegan (Hubbs 1918); STEPHENSON COUNTY: Freeport (H. Garman 1892); WILL COUNTY: Joliet (Hubbs 1918); New Lenox (Schmidt & Necker 1935).

Bufo americanus charlesmithi Bragg
Dwarf American Toad

Bufo terrestris charlesmithi Bragg 1954:247
(type locality: 1.8 mi. S, 7 mi. E Norman,
Cleveland County, Oklahoma).

Bufo lentiginosus americanus nec Holbrook,
?Yarrow 1882a:166 (part).

?*Bufo americanus nec* Holbrook, Burt & Burt
1929:2.

Bufo americanus americanus nec Holbrook,
Cagle 1942a:179.

Diagnosis.—A small to medium-sized race of *Bufo americanus* (largest Illinois specimen 69 mm. from snout to vent but usually less than 60 mm. at sexual maturity), fig. 61, differing from *B. a. americanus* in the following characteristics: smaller size; plain or sparsely spotted venter; head length usually more than 30 per cent of snout-vent length (in 80 per cent of specimens); somewhat greater parotoid length; dorsal spots, if present, small and including a single wart (83 per cent of specimens).

Remarks.—Although the dwarf form (*B. a. charlesmithi*) and the large form (*B. a. americanus*) are difficult to distinguish because of the overlap in characters, there is little doubt that these two forms represent distinct biological entities in Illinois. Whatever its status, the dwarf race has a considerable range. Parker (1939) illustrated a specimen from Reelfoot Lake, Tennessee, where it is reportedly uncommon, and I have seen specimens in central Arkansas and southern Missouri.

Variation.—Like the large form, *B. a. charlesmithi* is characterized by sexual dimorphism. Also, there is some evidence that in *B. a. charlesmithi* the males tend to be unicolorous, whereas females have obscure, dorsolateral light bands on a reddish ground-color.

No information is available on ontogenetic variation. The few juvenile specimens available are small replicas of the adults.

Geographic variation for three samples is summarized in table 17. The number, length, and proportions are for sexually mature specimens. The variation in dorsal and ventral patterns, however, is for both adults and juveniles.

Habits.—The dwarf American toad, uncommon in Illinois, is apparently a forest animal. Otherwise, it is probably similar to the large form in habits. Breeding aggregations of the small form have been encountered on a few occasions in flooded fields and shallow ditches on the Mississippi River floodplain. Most specimens at hand, however, have been found in steep-sided excavations that were too deep for the toads to climb or jump from. The ecological relationships of this toad with Fowler's toad need study.

The peak of the breeding season appears to be the first half of April. The call is a prolonged, high trill that I cannot distinguish from the song of the large form. The eggs are laid in long strings, and there is a single row of eggs within each string. The individual eggs range from 1.5 to 2.0 mm. in diameter. Additional observations are

Table 17.—Geographic variation in Illinois *Bufo americanus charlesmithi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	POPE COUNTY		UNION COUNTY		MONROE COUNTY	
	Range (5)	Mean	Range (9)	Mean	Range (5)	Mean
Snout-vent length (mm.)	52.8–68.0		42.8–56.0		48.0–69.5	
Head length as percentage of body length	29.8–33.9	31.8	28.6–34.2	31.6	28.8–31.8	31.1
Parotoid length as per cent of body length	21.8–22.8	22.4	18.4–23.4	21.3	19.4–24.2	21.3
	Range (8)	Mean	Range (13)	Mean	Range (7)	Mean
Ventral pattern index*	1–5	2.5	1–4	2.7	1–5	3.0

*Ventral pattern indicated by index number. The index numbers have been assigned as follows: venter immaculate or with a single pectoral spot, 1; a few scattered spots on the breast region, 2; a zone of dark spots across the breast, 3; entire venter spotted, 4; venter predominantly dark, 5.

needed to confirm the apparent difference between the two forms in number of rows of eggs per strand. I have not seen tadpoles, but it is likely that transformation occurs in late May and early June.

Illinois Distribution.—The occurrence of *B. a. charlesmithi* is sporadic, fig. 62; this toad is subordinate in numbers to *B. woodhousei fowleri* even in the forested Shawnee Hills, where it is best known. Since adequate samples of *B. americanus* are not available from the Southern Division, the subspecific status of the toads from this area is uncertain. The rarity and the consistently small size of the few specimens known from this part of the state strongly suggest the dwarf race.



Fig. 62.—Distribution of *Bufo americanus*. Vertical hatching indicates the presumed range of *Bufo americanus americanus* in Illinois; horizontal hatching, the presumed range of *Bufo americanus charlesmithi*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

The Richland County records of Cope (1889) and Gaige (1914) have not been accepted here, because Cope's Olney material that is still extant contains only *B. w. fowleri*. Moreover, Mrs. Gaige in her paper failed to mention Fowler's toad, which is so abundant in Richland County that it is inconceivable it would have been overlooked. There is some doubt concerning the Marion County record of H. Garman (1892) and the Washington County record of Burt & Burt (1929), but since there are recent collections of *B. americanus* in Bond, Clinton, Macoupin, and Montgomery counties, Garman's and Burts' records may be valid. No records for either race of *americanus* are known for the Wabash Border division.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: MADISON COUNTY: (Hurter 1911); MARION COUNTY: Centralia (H. Garman 1892); ST. CLAIR COUNTY: (Hurter 1911); WASHINGTON COUNTY: Nashville (Burt & Burt 1929).

Bufo woodhousei fowleri Hinckley Fowler's Toad

- Bufo fowleri* Hinckley 1882:310 (type locality: Milton, Massachusetts); Hubbs 1918:42-3.
Bufo woodhousii fowleri, Necker 1938:2.
Bufo woodhousei fowleri, Schmidt 1953:67.
Bufo lentiginosus americanus nec Holbrook, ?Yarrow 1882a:166.
Bufo lentiginosus lentiginosus, H. Garman 1890:189-90.
Bufo americanus nec Holbrook, ?Gaige 1914:4.

Diagnosis.—A medium-sized gray or greenish gray *Bufo* (largest Illinois specimen 69 mm. from snout to vent), fig. 63, typically with 2 or 3 pairs of large dark blotches between the parotoid region and anus, each blotch containing 3 or more warts; tibial warts never conspicuously enlarged; belly never spotted; breast usually with a single pectoral spot in specimens from southern Illinois, often with numerous dim spots in specimens from northern and central Illinois; cranial crests present but not strongly developed; throat of male black.

Variation.—In this toad, the male differs from the female in being smaller in size and in having a dark throat; also it has horny growths on the upper surfaces of the inner fingers.

Juveniles differ from adults chiefly in size. The newly transformed toadlet is clearly recognizable as Fowler's toad. The partially grown specimen lacks the clearly defined tympanum of the adult. The parotoid glands are proportionately larger. The parotoid length of seven specimens less than 40 mm. in body length averages 21.7 per cent of the snout-vent length, whereas the average parotoid length of seven adults over 58 mm. is 20.6 per cent.

The available series indicate an increasing frequency, from south to north, of individuals with spotted breasts. This variation is not strictly clinal in nature, but a general trend is discernible, as shown in table 18. It is noteworthy that all of the 23 specimens available from the Henderson-Mercer county sand area in northwestern Illinois are spotted beneath and would therefore key out as *B. americanus* by the most frequently employed character in anuran keys.



Fig. 63.—A subadult *Bufo woodhousei fowleri* from Tazewell County, Illinois. The ground-color is light gray, tan, or greenish gray; the spots are dark brownish black.

Table 18.—Geographic variation in ventral pattern of Illinois *Bufo woodhousei fowleri*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHERN HALF OF ILLINOIS (133)	NORTH-CENTRAL ILLINOIS (47)	EXTREME NORTHWESTERN ILLINOIS (23)	EXTREME NORTHEASTERN ILLINOIS (14)
Breast spotted (per cent of specimens with).....	18.2	54.7	100.0	14.0
Pectoral spot only (per cent of specimens with).....	81.8	45.3	0.0	86.0

Habits.—Fowler's toad is one of the most conspicuous amphibians in the southern half of Illinois and it is abundant in almost all suitable habitats. It may be encountered day or night; during the hottest part of the summer it is found less frequently during



Fig. 64.—Distribution of *Bufo woodhousei*. Hatching indicates the presumed range of the subspecies *fowleri* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

the day than at night. This toad feeds on insects and probably on earthworms; captive individuals, however, are reluctant to eat worms.

Breeding occurs from late April until late June, the peak occurring in mid-May. The song is a prolonged nasal scream. The eggs are laid in long strings similar to those of *B. americanus charlesmithi*. Hatching occurs in approximately a week, and the tadpoles transform from late June through July.

Illinois Distribution.—Fowler's toad is extremely common in the southern half of Illinois, fig. 64. In west-central Illinois, it is abundant along the Mississippi and Illinois rivers, which provide sand areas or sandy floodplains. In the Mississippi River valley north of Mercer County, an area containing seemingly ideal habitat of sand prairie, records for Fowler's toad are lacking, despite considerable field work in northwestern Illinois and adjacent Iowa. In east-central Illinois, these toads are extremely sporadic in occurrence in the black soil north of the Shelbyville Moraine.

Where *B. woodhousei fowleri* and *B. a. americanus* occur together in northern Illinois, there is a tendency for *fowleri* to occupy sandy areas and stream or lake margins. Evidence that a combination of soil type and temperature is more important than competition with the American toad in determining the range of *B. w. fowleri* is given by (1) a close correlation of species abundance and soil type in eastern Illinois and (2) a northward extension of the *fowleri* range along the shores of the Great Lakes, which presumably moderate the climate.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JOHNSON COUNTY: 20 mi. N Metropolis (Blanchard 1924b); PULASKI COUNTY: Villa Ridge (H. Garman 1892).

HYLIDAE

This world-wide family contains four or five genera in the United States and Canada, the number depending on the viewpoints of various authors.

Acris Duméril & Bibron

Many authors regard the strictly North American genus *Acris* as monotypic and refer the several described, but poorly defined, subspecies to *Acris gryllus* Le Conte. The conspecificity of Coastal Plain *gryllus* and inland *crepitans* has not been demonstrated, however, and the race occurring in Illinois is accordingly considered a subspecies of *crepitans*. The cricket frogs in Illinois seem to belong to a single, rather homogenous population. Their characters are in essen-

tial agreement with those of the recently described *blanchardi* (Harper 1947). Accordingly, the Illinois frogs are provisionally assigned to *blanchardi*, even though this subspecies is doubtfully distinct from *A. crepitans crepitans*.

***Acris crepitans blanchardi* Harper**
Blanchard's Cricket Frog

Acris gryllus blanchardi Harper 1947:39 (type locality: meadow near Smallen's Cave, Ozark, Christian County, Missouri).

Acris gryllus gryllus nec Le Conte, Yarrow 1882a:169.

Acris gryllus, S. Garman 1884:44.

Acris gryllus crepitans × *gryllus*, Cope 1889: 325, 331.

Acris gryllus crepitans nec Baird, Yarrow 1882a:169.

Acris crepitans, Schmidt & Necker 1935:64-5.

Diagnosis.—A small hylid frog (largest Illinois specimen 31.2 mm. from snout to vent), fig. 65, with digital discs scarcely

wider than penultimate joints; extensively webbed feet; pointed head; tibia 58 per cent or more of body length; usually a few to many dorsal warts; light line from each eye to shoulder; dark postfemoral stripe on each leg; numerous vertical, light bars on snout.

Variation.—During the breeding season of Blanchard's cricket frog the male is easily distinguished from the female by the discolored throat and vocal pouch. Other dimorphism has not been noted in the Illinois series.

I have been unable to find ontogenetic variation other than size.

A study of adequate series reveals only minor geographic variation for this frog in Illinois. There is some indication that specimens in the southern fifth of the state are relatively small, the largest of a series of 37 specimens from this region being only 28 mm. from snout to vent. The largest specimens in series from other areas exceed this



Fig. 65.—An adult *Acris crepitans blanchardi* from McLean County, Illinois. The ground-color may be gray, brown, black, olive, or tan; the markings, when present, are green, olive, or rusty red.

Table 19.—Geographic variation from north to south in tibia length to body length ratios of Illinois *Acris crepitans blanchardi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME NORTHERN ILLINOIS (34)		NORTH- CENTRAL ILLINOIS (19)		SOUTH- CENTRAL ILLINOIS (29)		EXTREME SOUTHERN ILLINOIS (44)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Tibia length as percentage of body length.....	55.6-69.6	59.6	55.3-70.0	60.9	55.0-69.9	61.2	55.9-67.8	61.4

length by 1 to 3 mm. Data for 157 specimens indicate that individuals from the northern half of Illinois tend to be more rugose than those from the southern half. The available data on color and pattern types indicate that individuals with green, or more rarely rust-colored, middorsal marks occur with greatest frequency in the Shawnee Hills division and with least frequency in the Mississippi Border counties.

A slight leg-length gradient is discernible from south to north, but no east-west cline is apparent. The leg-length variation is summarized in table 19.

Habits.—This cricket frog is the most common amphibian in Illinois, and almost any wet place affords suitable habitat. Although *Acris* is a hylid, it is like a true frog in habits. The digital pads are minute, and the species is aquatic and terrestrial but not arboreal. This frog is alert and capable of making leaps astounding for its small size. It is reluctant to hibernate and it has been found active as early as February and as late as December. Its food consists of minute arthropods.

Although the adult cricket frogs are able to tolerate near freezing temperatures without becoming inactive, the breeding season is late. Singing commences about the last of April in Illinois and continues throughout the summer. The males float on the surface or sit on masses of algae while uttering their metallic "gick, gick, gick." The small eggs are deposited as surface films of about a half dozen in each packet; one female may produce over 200 eggs. The tadpole is easily distinguished by its black-tipped tail. Metamorphosis apparently occurs from July through September, the time depending on when the eggs were laid.

Illinois Distribution.—The cricket frog is abundant in all parts of the state, fig. 66.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Deer Grove Park, Evanston, Wolf Lake (Necker 1939c); DU PAGE COUNTY: Glen Ellyn, Naperville (Schmidt



Fig. 66.—Distribution of *Acris crepitans*. The subspecies *blanchardi* occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

& Necker 1935); HENRY COUNTY: Colona, Geneseo (H. Garman 1892); JACKSON COUNTY: 2 mi. S Elkhville (Burt & Burt 1929); KANE COUNTY: Dundee (Stille & Edgren 1948); Geneva (H. Garman 1892); LAKE COUNTY: Highland Park (Schmidt & Necker 1935); Fox Lake (Necker 1939c); McHENRY COUNTY: Richmond (Schmidt & Necker 1935); MACOUPIN COUNTY: Standard City (Owens 1941); MORGAN COUNTY: Meredosia (Weed 1923); OGLE COUNTY: Grand Detour (Yarrow 1882a); PEORIA COUNTY: Peoria (H. Garman 1892); PERRY COUNTY: Tamaroa (Burt & Burt 1929); TAZEWELL COUNTY: Pekin (H. Garman 1892); UNION COUNTY: 7 mi. S Anna (Burt & Burt 1929); WABASH COUNTY: Mount Carmel (Cope 1889); WILL COUNTY: 3 mi. N Beecher (Burt 1935); Lockport, Marley (Necker 1939c); New Lenox, Wheatland Township (Schmidt & Necker 1935).

Pseudacris Fitzinger

This strictly North American genus of terrestrial hylids contains seven species, three of which consist of several subspecies. Two species are known in Illinois.

Pseudacris triseriata (Wied)

This species, as currently defined, includes three subspecies in the United States and Canada. Two of these occur in Illinois. For many years the three subspecies here assigned to *triseriata* and the southeastern chorus frogs, *nigrita* and *verrucosa*, were considered subspecies of *Pseudacris nigrita*. Schwartz (1957) demonstrated that the forms *nigrita* and *feriarum* behave as full species in the Coastal Plain of South Carolina and recommended the taxonomic arrangement here employed. *P. triseriata* and *P. nigrita* are actually intermediate between the specific and subspecific levels of differentiation; for, although they are specifically distinct in South Carolina, Georgia, and Florida, they are not so in southern Mississippi, where they behave as subspecies.

Pseudacris triseriata feriarum (Baird) Upland Chorus Frog

Helocaetes feriarum Baird 1854a:60 (type locality: Carlisle, Cumberland County, Pennsylvania).

Chorophilus nigritus feriarum, Jordan 1888:360.

Chorophilus feriarum, Cope 1889:341.

Pseudacris feriarum, Stejneger & Barbour 1917:30.

Pseudacris nigrita feriarum, Stejneger & Barbour 1933:32.

Chorophilus triseriatus nec Wied, H. Garman 1892:343-5 (part).

Pseudacris triseriatus nec Wied, Schmidt 1938a:380 (part).

Pseudacris nigrita triseriata nec Wied, Cagle 1941:6 (part).

Pseudacris nigrita nec Le Conte, P. W. Smith 1948:2.

Diagnosis.—A small hylid frog (largest Illinois specimen 32 mm. from snout to vent), fig. 67, without webbing between the toes; toes with slightly expanded discs; dorsum smooth to granular; venter granular or pustular; a light maxillary stripe; usually a triangular-shaped interorbital marking; distinct longitudinal lateral stripes; 3 longitudinal dorsal stripes or series of spots or flecks derived from 3 stripes; tibia 47 per cent or more of snout-vent length; head length 32 per cent or more of snout-vent length; and often with a tan or red brown groundcolor.

Variation.—In this frog the male differs from the female in being smaller in size and in having slightly enlarged thumbs and longitudinal gular folds. During the breeding season, the throat of the male is discolored and the vocal pouch is evident because of its dark color.

Juveniles differ from adults chiefly in their proportionately larger heads and longer tibiae.

Individual variation in this frog is pronounced both in pattern and in habitus. Typically, the pattern consists of a distinct stripe along each side and 3 weak, and often interrupted, dorsal stripes. Occasional specimens are flecked with uniformly distributed dark markings above, and infrequent specimens are unicolorous above. Other individuals are broadly striped above, as in *Pseudacris triseriata triseriata*. The groundcolor ranges from gray-green to red-brown. Some specimens are slender, with conspicuously widened heads; others are squat, differing from *P. t. triseriata* only by their longer legs.

In a series of 42 specimens from the extreme southern tip of the state the tibia length is 43.6 to 58.4 (average 50.7) per cent of body length and the head length (for

23 specimens) 29.6 to 37.5 (average 34.5) per cent of body length. (average 48.7) per cent of body length; head length (for 12 specimens), 30.9 to 34.1 (average 32.3) per cent of body length.

In a series of 20 specimens from the Shawnee Hills, the tibia length is 44.9 to 52.0 Geographic variation in *P. t. feriarum*



Fig. 67.—An adult *Pseudacris triseriata feriarum* from Saline County, Illinois. The ground-color is tan, gray, or light reddish brown; the weak dorsal stripes or spots are usually dark brown.

Table 20.—Geographic variation in tibia length to body length ratios of Illinois *Pseudacris triseriata feriarum* × *triseriata* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	JACKSON-SALINE COUNTIES (16)		JEFFERSON-WABASH COUNTIES (16)		RICHLAND COUNTY (48)		CLARK-CRAWFORD COUNTIES (4)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Tibia length as percentage of body length.....	42.6-51.1	46.3	43.6-54.7	47.4	43.3-51.1	47.3	39.0-53.7	46.5

has been described elsewhere (Smith & Smith 1952). In Illinois the most pronounced variation is manifested by populations which intergrade with the northern, shorter-legged race, *triseriata*. Samples from the intergrading area do not exhibit the regular, accelerated cline from long legs to shorter legs, as might be expected. Instead, the characters of the two races are so intermingled that one sample may be referred to *feriarum* while one from an adjacent locality may be referred to *triseriata*. The erratic nature of the intergrade population is illustrated by four samples, table 20.

Habits.—*P. t. feriarum* is essentially a forest animal, occurring on floodplains and in mesic upland woods except during the breeding season, when it may be found around almost any type of temporary pool. In summer this frog is sometimes seen on the forest floor or perched on herbaceous plants in swampy places. It feeds on small arthropods.

Breeding occurs in temporary ditches or pools from late February until May, the peak occurring in mid-March. The male sings while perched at the edge of a pool or floating in the water; its call is similar to the noise made by rubbing a thumbnail over the teeth of a comb. The female deposits approximately 100 small eggs in

elongate clusters that are attached to vegetation or sticks. Hatching occurs in a few days, and the tadpoles transform in May and June.

Illinois Distribution.—This subspecies occurs in the southern tip of Illinois, fig. 69, and intergrades with *P. t. triseriata* throughout the Wabash River valley from Saline to Clark counties.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: WABASH COUNTY: Mount Carmel (Cope 1889).

***Pseudacris triseriata triseriata* (Wied)**
Western Chorus Frog

Hyla triseriata Wied 1839:249 (type locality: Rush Creek, approximately 4 mi. S New Harmony, Posey County, Indiana); Kennicott 1855:593.

Pseudacris nigrata triseriata, Hurter 1893:254.

Pseudacris triseriata, Weed 1923:49.

Helocaetes triseriatus, Baird 1854a:60.

Chorophilus triseriatus triseriatus, Yarrow 1882a:170.

Chorophilus triseriatus, Cope 1889:343, 347.

Pseudacris triseriatus, Schmidt 1929:10-1.

Chorophilus nigratus nec Le Conte, Shelford 1913:195, 206, 283, 296.

Pseudacris nigrata nec Le Conte, P. W. Smith 1948:2.



Fig. 68.—An adult *Pseudacris triseriata triseriata* from McLean County, Illinois. The groundcolor is tan, gray, or greenish gray; the dorsal stripes are dark olive or brownish black.

Pseudacris feriarum nec Baird, Pope 1919: 83-4.
?Acris gryllus nec Le Conte, Ridgway 1915: 94, 95.

Diagnosis.—A subspecies of *Pseudacris triseriata* (largest Illinois specimen 36 mm. from snout to vent), fig. 68, differing from *P. t. feriarum* in having shorter legs (tibia less than 47 per cent of snout-vent length in 95 per cent of specimens); proportionately wider body and smaller head (head length less than 32 per cent of snout-vent length in 80 per cent of specimens); usually a distinct triseriate dorsal pattern; and usually a gray, gray-green, or slate ground-color.

Variation.—Sexual variation and ontogenetic variation are apparently identical in the two Illinois subspecies of *P. triseriata*. Individual variation involves occasional reduction of the striped pattern and differences in proportions, although specimens of this race are somewhat less variable than those of *feriarum*. No marked geographic variation, exclusive of the intergrading populations described under *P. t. feriarum*, has been discerned, but there is an indication that extreme northern Illinois specimens of *triseriata* may average a bit smaller than those from central Illinois. The absence of a leg-length gradient has been pointed out elsewhere (Smith & Smith 1952). Variation in pattern and proportionate head size is similarly nongeographic. The leg-length variation in four samples is given in table 21.

Habits.—The western chorus frog appears in temporary pools and ditches in great numbers early in the spring, and its voice is the most familiar frog sound in Illinois. After the breeding season, this species is seldom seen, and its habitat is not well known. Occasional specimens have been taken in summer and fall under rocks,

grain shocks, or other objects. It is essentially a prairie animal, and it thrives in the most intensively cultivated regions of the state. Individuals encountered out of water progress by short, rapid hops and often try



Fig. 69.—Distribution of *Pseudacris triseriata*. Vertical hatching indicates the presumed range of *Pseudacris triseriata triseriata* in Illinois; horizontal hatching, the presumed range of *Pseudacris triseriata feriarum*; cross-hatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Table 21.—Geographic variation in tibia length to body length ratios of Illinois *Pseudacris triseriata triseriata*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	JASPER COUNTY (32)		MORGAN-BROWN COUNTIES (20)		CHAMPAIGN COUNTY (25)		COOK-LAKE COUNTIES (30)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Tibia length as percentage of body length.....	40.3-45.9	43.6	39.6-44.5	42.0	37.1-47.1	42.5	38.1-45.9	42.7

to secrete themselves under objects or in cracks in the ground. Its food consists of small arthropods.

Breeding occurs from early March into May, the peak occurring in late March. The song, egg-laying habits, and development are presumably similar to those of *P. t. feriarum*, although both hatching and transformation occur later in the season than in *feriarum*.

Illinois Distribution.—*P. t. triseriata* occurs commonly throughout Illinois except in the southern tip of the state, where it is replaced by *P. t. feriarum*, and in the Wabash River valley, where it is replaced by a *feriarum* × *triseriata* intergrade population, fig. 69.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Deer Grove (Necker 1939c); Palatine (Schmidt & Necker 1935); West Northfield (Yarrow 1882a); DU PAGE COUNTY: Downers Grove (Schmidt & Necker 1935); KANE COUNTY: Elgin (Schmidt & Necker 1935); LAKE COUNTY: Beach (Schmidt & Necker 1935); Fort Sheridan (Pope 1919); Fox Lake, Half Day, Highland Park (Schmidt & Necker 1935); Volo, Waukegan (Necker 1939c); MADISON COUNTY: Mitchell (Hurter 1893); OGLE COUNTY: Oregon (H. Gar-

man 1892); ST. CLAIR COUNTY: Bluff Lake (Hurter 1893); WILL COUNTY: Lockport (Schmidt & Necker 1935).

***Pseudacris streckeri illinoensis* Smith**
Illinois Chorus Frog

Pseudacris streckeri illinoensis, P. W. Smith 1951:190 (type locality: 3 mi. N Meredosia, Morgan County, Illinois).

Pseudacris streckeri illinoensis, Schmidt 1953: 76.

Pseudacris feriarum brachyphonus nec Cope, Weed 1923:49.

Pseudacris sp., Walker 1932:382.

Diagnosis.—A medium-sized hyloid frog (largest Illinois specimen 42 mm. from snout to vent), fig. 70, with a toadlike habitus; vestigial webs; intercalary cartilage; digital pad smaller than penultimate phalanx; lateral dark stripe from snout to shoulder; upper jaw light, with a prominent, dark suborbital spot; a dark interorbital V- or Y-shaped marking; and groin the same color as the dorsal groundcolor.

Variation.—In the Illinois chorus frog, the male differs from the female in having a vocal pouch and being smaller in size. During the breeding season the throat of the male is discolored.

Newly transformed individuals of this subspecies are dull gray, and their dorsal pattern is inconspicuous. The single known subadult differs slightly in proportions from



Fig. 70.—Adult *Pseudacris streckeri illinoensis* from Cass County, Illinois. The groundcolor is tan, flesh color, or light bronze; the markings are light brown to chestnut brown.

mature specimens. This subadult, 28 mm. from snout to vent, has a tibia length 46.4 per cent and a head length 36.1 per cent of the snout-vent length. Ten adults at hand have tibia lengths 39.7 to 42.4 (average 41.0) per cent and head lengths 29.8 to 32.4 (average 30.8) per cent of the snout-vent lengths.

The specimens obtained since the original description appeared (P. W. Smith 1951) have not appreciably altered the known range of individual variation. At the time of the original description, one of the supposedly diagnostic features of *Pseudacris streckeri illinoensis* was the reduced lateral stripe (82 per cent of specimens with dark stripe no larger than postorbital stripe). Examination of additional material reveals that this character is of questionable value. However, the diagnostic value of the groin color and groin pattern, the two principal characters utilized, has been substantiated by an examination of additional specimens of *P. s. illinoensis*, as well as of *P. s. streckeri*. In addition, the greenish ground-color of the dorsum, which is of frequent occurrence in *P. s. streckeri*, apparently never occurs in *P. s. illinoensis*.

Approximately 75 per cent of the specimens available possess a dark, inverted Y-shaped marking on one or both shoulders, with the inner prong usually extending to the middle of the back. The dorsum bears a few dark bars and occasionally round, dark spots posteriorly.

Habits.—This frog is known only from specimens taken during the breeding season, and accordingly its habitat is unknown. It is abundant in the small area in which it is known; during the breeding season, choruses can be heard continuously along the highways in the area. *P. s. illinoensis* is terrestrial and probably similar to *P. triseriata triseriata* in behavior. On land it progresses by short, toadlike hops. Captives have eaten various insects that were obtained in a sweeping net such as is used for collecting insects.

Breeding in this subspecies occurs from the first to the last of March. The call of the male is a series of short, loud, birdlike whistles. The female lays approximately 400 eggs; the number in each mass and the shape of the mass are not known. Large tadpoles taken in mid-May transformed in the laboratory in late May and early June.

Illinois Distribution.—Since originally described, this frog has been found in an additional Illinois county and in a sand prairie in extreme southeastern Missouri. The total known range, fig. 71, occupies only four Illinois counties and one locality



Fig. 71.—Distribution of *Pseudacris streckeri*. Hatching indicates the presumed range of the subspecies *illinoensis* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

in Missouri. To date, attempts to find the frog in other sand areas in the state have been unsuccessful, but there is some possibility that it occurs in the Oquawka sand prairie and perhaps also in the Iroquois-Kankakee sand area.

The relationships of this subspecies and its nearest relative, which occurs in central Oklahoma and Texas, have been discussed in the original description of *P. s. illinoensis*. The discovery of this animal in central Illinois is of some zoogeographic importance in that it provides additional evidence to support the Prairie Peninsula hypothesis and

the occurrence of a post-glacial xerothermic period.

Hyla Laurenti

The cosmopolitan genus *Hyla* contains 12 or 14 species in the United States and Canada, the number depending upon the taxonomic viewpoints of different authors. Many of the species consist of two or more subspecies. Four species occur in Illinois.

Hyla avivoca avivoca Viosca Western Bird-Voiced Treefrog

Hyla avivoca Viosca 1928:89 (type locality: Mandeville, Louisiana); Harper 1933:230.

Hyla phaeocrypta, Viosca 1923:96-7 (part).
Hyla versicolor phaeocrypta, Wright & Wright 1933:134 (part).

Hyla phaeocrypta phaeocrypta, Schmidt 1953:71-2.

Diagnosis.—A small, slender, smooth-skinned *Hyla* (largest Illinois specimen 36.5 mm. from snout to vent), fig. 72, with a gray

59 per cent of eye diameter; and subarticular pustule on outer finger of hand usually divided.

Variation.—The male is considerably smaller than the female in this frog and it possesses either a discolored throat or longitudinal folds, which indicate the presence of a vocal sac.

No information on ontogenetic variation is available for Illinois populations of *Hyla avivoca avivoca*. Hellman (1953) noted that newly transformed frogs of the Florida population are about 13 mm. in snout-vent length, are pea-green above, and possess prominent suborbital light spots.

Individual variation in a series of 31 Union County specimens is as follows: snout-vent length 27.8 to 36.5 mm.; head length 28.3 to 31.6 (average 29.9) per cent of body length; tibia length 45.0 to 52.7 (average 48.5) per cent of body length; eye



Fig. 72.—An adult *Hyla avivoca avivoca* from Union County, Illinois. The groundcolor varies from pale gray to light green to almost black; the markings are dark gray, brown, or black.

or green groundcolor and usually an asymmetrical, star-shaped, dark dorsal blotch; distinct suborbital light spot; wash of green color in groin and on rear of thighs in which black or brown reticulations or spots are present; relatively large eyes (33 to 44 per cent of head length); tympanum 43 to

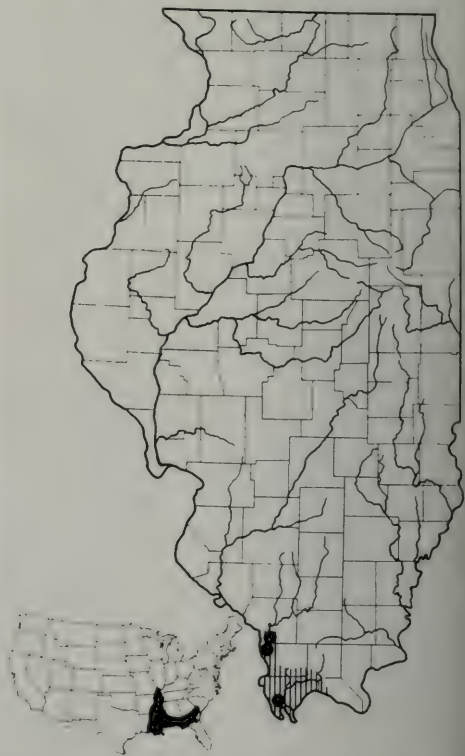


Fig. 73.—Distribution of *Hyla avivoca*. Hatching indicates the presumed range of the subspecies *avivoca* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

33.0 to 43.5 (average 37.4) per cent of the head length; eye 28.6 to 35.3 (average 32.7) per cent of head width; tympanum 43.1 to 59.1 (average 49.1) per cent of eye diameter. The dorsal blotch is variable in size and shape. Metachrosis is well developed in *H. a. avivoca*, and living frogs may be light green, light enamel gray, or almost black.

Habits.—The western bird-voiced treefrog has been seldom collected except in breeding choruses, but its normal habitat is likely identical with the breeding site, which is cypress swamps. Breeding individuals are found above the water of the swamps, on vines, tree branches, or stems of *Cephalanthus*. Captives usually change from gray or black to light green when placed in dry, well-lighted containers.

Breeding in this treefrog occurs in southern Illinois from mid-May into August. The call of the male is a prolonged, quavering, birdlike note. Eggs have not been found in Illinois. Hellman (1953) found that Florida females contain 600 or more ovarian eggs, which are subsequently laid in submerged packets. Hatching occurs in 3 or 4 days, and the larval period requires

about a month. The tadpole of both the Florida and Illinois populations is dark brown, with 3 to 7 red saddles and thin bronze-colored stripes on the head.

Illinois Distribution.—This species is known to extend into Illinois only as far as extreme southern Jackson County, fig. 73. It is abundant in the floodplain swamps of western Union and Alexander counties, but efforts to secure specimens in similar swamps of adjacent Massac, Johnson, and Pulaski counties have been unsuccessful.

Hyla cinerea (Schneider)
Green Treefrog

Calamita cinereus Schneider 1799:174 (type locality: Carolina; revised to Charleston, South Carolina, by Schmidt 1953).

Hyla cinerea, H. Garman 1890:189.

Hyla cinerea cinerea, H. Garman 1892:346-8.

Hyla lateralis, Brendel 1857:254.

Hyla cinerea semifasciata, H. Garman 1890:189.

Hyla carolinensis, Hay 1892a:585.

Diagnosis.—A large, slender *Hyla* (largest Illinois specimen 56 mm. from snout to vent), fig. 74, bright green or olive-



Fig. 74.—A subadult *Hyla cinerea* from Union County, Illinois. The groundcolor is normally bright leaf-green, occasionally olive-green; the lateral stripe, white; the dorsal flecks are gold.

green above, without markings or with scattered, minute gold flecks; white lateral stripes extending onto shoulder region or beyond; smooth skin; and with a longitudinal light stripe along the dorsal surface of the tibiotarsus.

Variation.—The male of *H. cinerea* averages slightly smaller than the female and has a wrinkled throat indicating the vocal pouches.

Cagle (1942a) found that the newly transformed frog of this species is green only on the back of the head and that 12 days are required for the entire dorsum to become green. The subadult appears less elongate and the head length range is 31 to 36 per cent of the body length (in 10 juveniles under 35 mm.), whereas the head length range is from 30.0 to 31.5 per cent in the adult (six specimens over 40 mm.). The tympanum is evident in all of our material, but it is proportionately larger in mature specimens.

Eighteen specimens from Alexander and Union counties, ranging from 22.6 to 55.8 mm. in snout-vent length, exhibit the following variation: tibia length 48.4 to 55.0 (average 53.2) per cent of body length; lateral stripes present, extending no more than half the distance from tympanum to groin in 33 per cent, and more than half in 67 per cent. There are one to many small gold flecks, sometimes black-margined, over the back in each of our specimens.

Habits.—The green treefrog is one of the most colorful of Illinois amphibians. It is found in cypress swamps, along floodplain sloughs, and in cattail marshes. During the day it usually perches on a cattail blade, with its legs tucked underneath the body; because of its green color, it is difficult to see. Captives sometimes turn olive-green, particularly when cold, but most wild individuals are bright leaf-green.

Breeding in the green treefrog occurs from mid-May until August. The call of the male is a measured and monotonous "quonk, quonk, quonk." A chorus imparts a distinct metallic sound, and the song has been compared to the sound of cowbells. Wright & Wright (1949) report that eggs are laid in small packets or films among floating vegetation, that hatching presumably occurs in a few days, and that the larval period is approximately 2 months. Cagle (1942a) found newly transformed

frogs the last of May, however, indicating that the eggs had been laid in late March or early April. Singing males have never been found earlier than May in southern Illinois. The life history of the species needs reinvestigation.

Illinois Distribution.—This species is known from the Mississippi and Ohio river floodplains in the extreme southern tip of Illinois, where it occurs in abundance, fig. 75. A Madison County record for *cinerea*, in which Hurter (1893) used the synonymous name *carolinensis*, is puzzling, for Hurter leaves little doubt that he was familiar with *cinerea*, inasmuch as the species with which it might be confused were reported in the same paper. Some doubt remains, however, since Hurter in a later paper (1911) failed to mention the

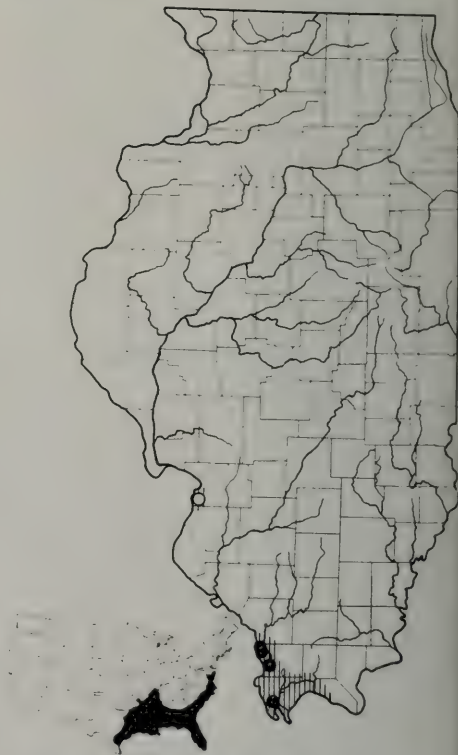


Fig. 75.—Distribution of *Hyla cinerea*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

Madison County locality, although he cited specimens from southeastern Missouri. I have not been able to find the species anywhere north of Union County.

***Hyla crucifer crucifer* Wied**
Northern Spring Peeper

Hyla crucifer Wied 1839:275 (type locality: Leavenworth, Leavenworth County, Kansas); Schmidt 1929:10.

Hyla crucifer crucifer, Pope 1944b:95-100.

Hyla pickeringii, Kennicott 1855:593.

Hyla pickeringi, Davis & Rice 1883a:28.

Diagnosis.—A small *Hyla* (largest Illinois specimen 34 mm. from snout to vent), fig. 76, tan or brown, usually with a distinct

pinkish cast; a prominent dark X-mark on the back and a dark mark between the eyes; toe pads distinctly wider than penultimate joints; snout projecting beyond mouth in lateral view; without suborbital light spot or light maxillary stripe.

Variation.—The male in this diminutive hylid is somewhat smaller than the female and possesses longitudinal gular folds, which permit expansion of the vocal pouch. During the breeding season, the throat of the male is discolored and saclike.

Juveniles tend to have a less well-defined dorsal pattern and the groundcolor is usually lighter.

Geographic variation is not pronounced in the Illinois series. Spring peepers from



Fig. 76.—An adult *Hyla crucifer crucifer* from Monroe County, Illinois. The groundcolor is pink or tan; the markings are brown.

Table 22.—Geographic variation in Illinois *Hyla crucifer crucifer*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (23)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (40)		NORTH-CENTRAL ILLINOIS (9)		EXTREME NORTHERN ILLINOIS (4)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.), maximum	34.0	.....	31.6	.....	30.0	.....	22.1	.....
Head length as percentage of body length.....	27.9-34.7	31.7	28.2-34.7	30.7	28.9-31.3	30.2	29.3-33.4	31.1
Tibia length as percentage of body length.....	46.8-55.7	51.2	44.9-53.0	48.9	42.6-48.5	46.0	47.3-49.8	48.7
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Without dark ventral flecks.....	43		28		3		5	

the northern part of the state, however, appear to be smaller in size and their venters are more often pigmented. The leg-length variation is irregular. Data for 76 specimens from four areas are summarized in table 22. The sample from extreme northern Illinois is actually from the northeastern corner of the state, and the strikingly shorter-legged frogs of this species from north-central Illinois are from the Illinois River sand area.

Habits.—The northern spring peeper occurs in mesic forest, living in trees or on herbaceous plants. It is normally abundant around woodland ponds early in the spring but difficult to find later in the season. Late in the fall, however, the male, whose gonads are again ripe, may begin singing from the woods. The peeper feeds on various small arthropods.

Breeding in this species occurs from early March to early June. The song is a soft, birdlike whistle and may be heard during the day or night at the peak of the breeding season. Diurnal singers usually are in trees or hidden under the leaves of the forest floor; at night peepers sing from the edge of the water or on vegetation over the water. The female deposits her several hundred eggs singly, and each egg is attached to a stick or other submerged object. Hatching

occurs in a few days, and the larvae transform in May and June.

Illinois Distribution.—Apparently the northern spring peeper is state-wide in occurrence, fig. 77; abundance varies widely in different parts of Illinois. In the northern half of the state it probably does not occur in small islands of forest surrounded by prairie or cultivated fields, but it is known in the more extensive wooded areas along rivers. The absence of records from the Upper Mississippi Border counties probably reflects the small amount of field work in this region during the peeper breeding season; the species is known in adjacent Iowa and Missouri.

Where peepers occur, they are much in evidence in spring because of their abundance and the carrying power of their penetrating birdlike calls. In Illinois they are sporadic in distribution. In adjacent Indiana a person can hear a continuous chorus of peepers as he drives along the highways in spring.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Homewood, Palos Park (Schmidt & Necker 1935); LAKE COUNTY: Beach (Schmidt 1929); ST. CLAIR COUNTY: (Hurter 1893).

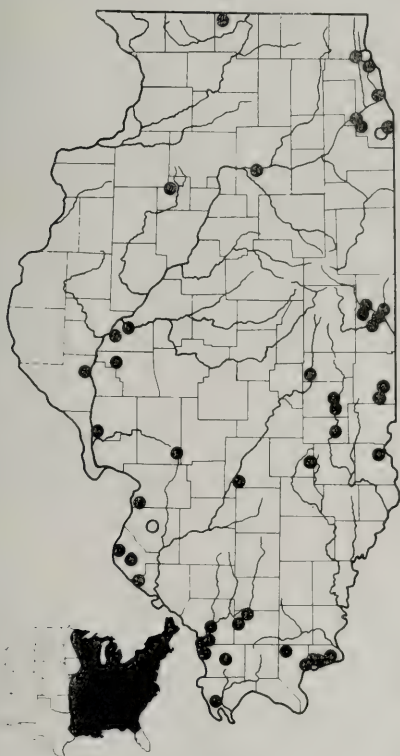


Fig. 77.—Distribution of *Hyla crucifer*. The subspecies *crucifer* occurs throughout Illinois mainly in extensive wooded areas. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

***Hyla versicolor versicolor* Le Conte**
Eastern Gray Treefrog

Hyla versicolor Le Conte 1825:281 (type locality: northern states; revised to vicinity of New York City by Schmidt 1953); Kennicott 1855:592.

Hyla versicolor versicolor, Blanchard 1924b:534.

Hyla versicolor phaeocrypta Cope 1889:375 (type locality: Mount Carmel, Illinois).

Hyla phaeocrypta, Viosca 1923:96-7 (part).

Hyla phaeocrypta, Burt 1928:630.

Diagnosis.—A large *Hyla* (largest Illinois specimen 57 mm. from snout to vent), fig. 78, with a suborbital light spot on each side of head; usually a star-shaped or irregular dark blotch on the back; dorsum tubercular or pustular; digital pads distinctly widened; posterior surfaces of thighs

with orange-yellow spots enclosed by a dark matrix or a loose reticulation of yellow and brown or black; a simple subarticular pustule on outer finger of hand usually present (70 per cent of specimens); tympanum usually 52 per cent or more of the diameter of eye.

Remarks.—Two Illinois populations are evident. In one, in the southern half of the state, the dark color on the rear of the femora encloses round yellow spots and the dorsal blotch is star shaped. In the other, in the northern half, the thighs are reticulated brown and yellow or uniformly yellow and the dorsal blotch is nondescript.

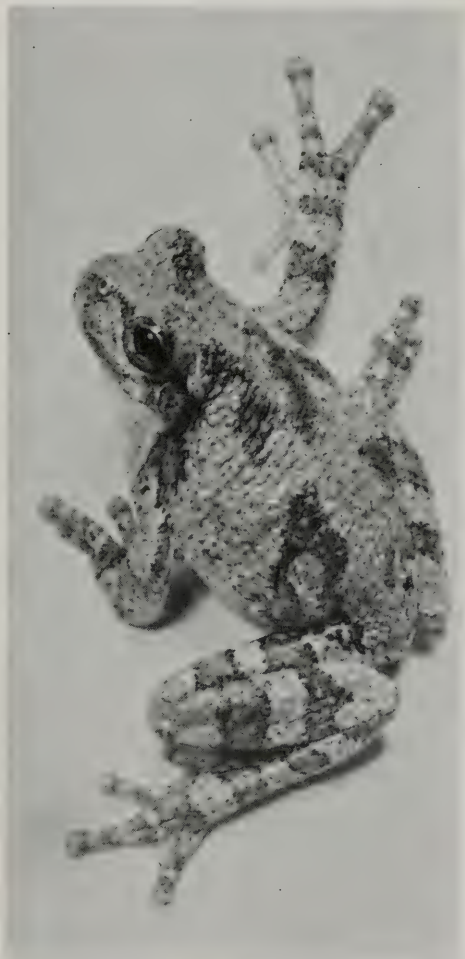


Fig. 78.—An adult *Hyla versicolor versicolor* from Union County, Illinois. The ground-color varies from pale gray to light green to almost black; the markings are dark gray, brown, or black.

Series intermediate between these pattern types are available from the Illinois River valley (the north-central Illinois sample in table 23).

There is a great deal of individual variation in specimens from any one locality, and the differences mentioned above are rather slight, particularly in preserved frogs. Accordingly, all the Illinois series are provisionally referred to *H. versicolor versicolor*, pending a detailed investigation of geographic variation in the species. There is some possibility that the population in the southern half of Illinois is assignable to *H. v. chrysocelis*, inasmuch as the frogs there appear to be identical with comparative material from Arkansas. If *chrysocelis* is valid, its range requires redefinition.

Variation.—In this treefrog the male is somewhat smaller than the female and, during the breeding season, is readily distinguished from the female by the presence of the discolored vocal pouch. In the male a process of the pad at the base of the thumb extends onto the upper surface of the thumb, whereas in the female this pad is restricted to the ventral and inner side of the thumb.

Newly transformed frogs of this species are green or gray-green. The characteristic

suborbital light spot and the postfemoral reticulation are not evident, but both appear in frogs of about 25 mm. from snout to vent. Proportionate head size and leg length are much the same in adult and juvenile. The proportionate size of the tympanum increases with larger body size. Thus, in 10 specimens under 28 mm. the tympanum averages 52.5 per cent of the diameter of the eye; in 22 specimens 28 to 36 mm. the tympanum is 58.2 per cent; in 27 specimens 36 to 45 mm. it is 60.1 per cent; and in 10 specimens over 45 mm. it is 62.4 per cent.

In addition to the differences in postfemoral patterns mentioned under "Remarks," both proportionate head length and proportionate leg length decrease toward the north, although the gradients are not steep. These trends are illustrated in table 23.

Habits.—The eastern gray treefrog inhabits forested areas. Although a tree animal, it is seen on the ground when it is migrating to breeding ponds. In the summer, particularly during dry weather, this treefrog lives in hollows of dead trees or under the bark of stumps or of moist, rotten logs. On three occasions individuals have been found in pump spouts of abandoned wells. Metachrosis in this treefrog is well developed, as

Table 23.—Geographic variation in Illinois *Hyla versicolor*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (28)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (29)		NORTH-CENTRAL ILLINOIS (36)		EXTREME NORTHERN ILLINOIS (22)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.).....	21.6-57.0	.....	23.0-49.3	.....	22.9-51.9	.....	31.2-43.8	.....
Head length as percentage of body length.....	28.8-33.8	31.5	28.0-34.6	30.7	27.9-34.8	30.4	28.1-30.9	29.7
Tibia length as percentage of body length.....	45.5-52.8	48.2	43.0-52.6	46.9	42.0-52.5	46.9	44.5-50.2	46.5
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With postfemoral pattern of <i>H. v. chrysocelis</i>	75.0		69.0		34.5		0	

the species name implies, and individuals often blend so well with tree bark that they are difficult to discern. Captives vary from almost black (usually when cold and wet) to enamel gray or light green (under optimum conditions). Individuals found in shaded floodplains in the summer and fall may be quite conspicuous in color. In such habitats they often perch at the tips of dead branches, and their almost white coloration is in sharp contrast to the black tree limbs. The food of the gray treefrog consists of various arthropods.

Breeding in this treefrog occurs from late April into August, the peak occurring in late May. The season varies with latitude, and males may occasionally sing late in the fall, when their gonads have again ripened.

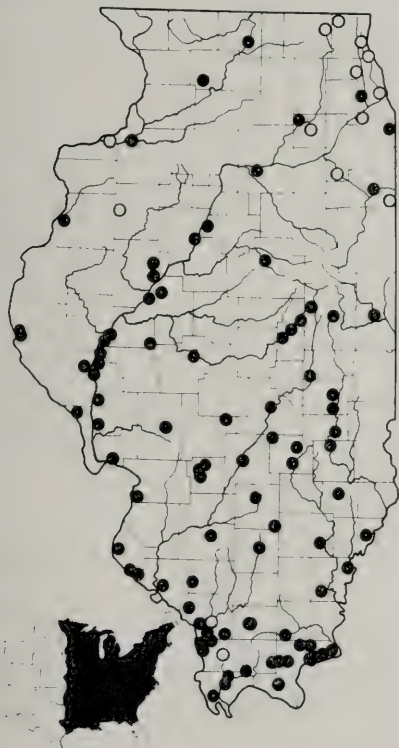


Fig. 79.—Distribution of *Hyla versicolor*. The subspecies *versicolor* occurs throughout Illinois wherever there are wooded areas. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

The call of the male is a loud, guttural trill. Singing males may be in trees or bushes, on the ground, or in the water. The breeding sites are extremely variable, ranging from water-filled automobile tracks to creeks or lakes. The packets of two or three dozen eggs are loosely attached to vegetation at the surface of the water. Hatching occurs in a few days, and the larvae transform from May to August. The tail of the tadpole is boldly marked with red and black.

Illinois Distribution.—The eastern gray treefrog commonly occurs in forested areas over all of Illinois, fig. 79. It may be absent from small islands of forest surrounded by prairie, but it occurs in narrow strips of forest along streams, even in areas predominantly prairie.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Aux Plaines (Yarrow 1882a); Chicago (Schmidt 1929); Willow Springs (Schmidt & Necker 1935); JACKSON COUNTY: Murphysboro (Cagle 1942a); KANKAKEE COUNTY: Hopkins Park, Pembroke Township (Necker 1939c); KENDALL COUNTY: Yorkville (H. Garman 1892); KNOX COUNTY: Galesburg (H. Garman 1892); LAKE COUNTY: Fox Lake (Necker 1939c); Half Day (Schmidt & Necker 1935); Highland Park (Schmidt 1929); McHENRY COUNTY: McHenry (Stille & Edgren 1948); ROCK ISLAND COUNTY: Rock Island (H. Garman 1892); UNION COUNTY: Anna (H. Garman 1892); WILL COUNTY: Custer Park (Stille & Edgren 1948).

RANIDAE

This family, which includes the typical frogs, occurs on all of the continents and ranges in latitudinal distribution from the Arctic Circle (North America) southward to Queensland (Australia). In the New World this large family contains only one genus.

Rana Linnaeus

This world-wide genus is represented in the United States and Canada by about 15 species, most of which consist of two or more subspecies each. Eight species and subspecies of *Rana* have been found in Illinois.

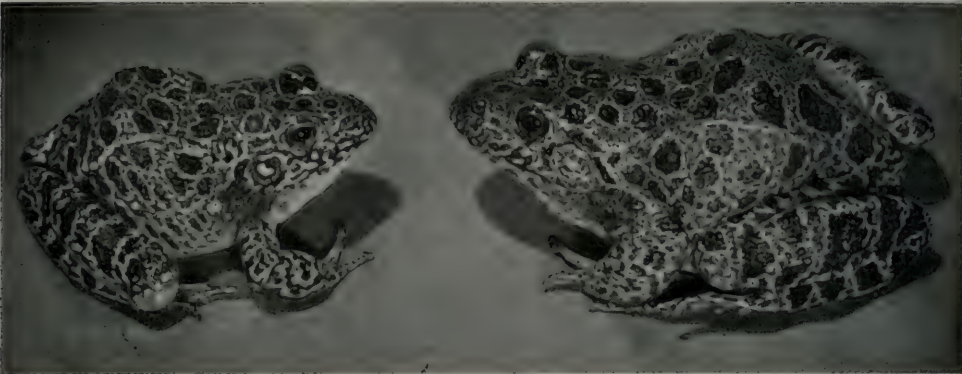


Fig. 80.—Adult *Rana areolata circulosa* from Marion County, Illinois. The groundcolor is milky white; the closely crowded spots are brown or black.

Rana areolata circulosa Rice & Davis
Northern Crayfish Frog Gopher Frog

Rana circulosa Rice & Davis 1878:355 (type locality: Benton County, Indiana; revised incorrectly to northern Illinois by Stejneger & Barbour 1943; corrected by Mittleman 1947; revised incorrectly to Richland County, Illinois, by Schmidt 1953).

Rana areolata circulosa, Davis & Rice 1883a: 28.

Rana aerolata circulosa, Peters 1942:182.

Rana areolata capito nec Le Conte, Yarrow 1882a:178.

Rana capito nec Le Conte, S. Garman 1884:41.

Rana areolata, H. Garman 1892:319–20.

Diagnosis.—A large *Rana* (largest Illinois specimen 109.8 mm. from snout to vent), fig. 80, with dorsolateral folds; conspicuously mottled upper jaws; prominent hump at the middle of the back; tympanum always smaller than eye; large head; conical snout; and milky white groundcolor visible at the margins of the many closely crowded, round, black spots.

Variation.—The female gopher frog averages larger than the male and possesses heavy glandular ridges under the tympanums. The male has a pair of saclike vocal pouches on the sides of the head and enlarged thumbs.

Ten newly transformed specimens, ranging from 22.5 to 24.5 mm. in snout-vent length, differ from sexually mature adults by their proportionately larger heads, shorter legs, more distinctly spotted dorsums, and less distinctly barred legs. Head length in 10 juveniles ranges from 39.6 to 41.0, averaging 40.2, per cent of the body length, whereas in 50 frogs over 57 mm. in snout-vent length it ranges from 30.0 to 37.1, averaging 33.3, per cent. Tibia length for the 10 juveniles ranges from 42.5 to 47.5, averaging 45.1, per cent of the body length, whereas in the 50 adult specimens it ranges from 34.9 to 53.9, averaging 48.8, per cent.

Data provided by three samples of adults suggest a slight reduction in proportional

Table 24.—Geographic variation in proportionate leg length in three Illinois samples of *Rana areolata*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EDGAR-COLES-CUMBERLAND COUNTIES (20)		LAWRENCE TO BOND COUNTIES (11)		WILLIAMSON COUNTY (21)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	65.9–109.8	.....	74.0–101.3	.....	57.2–106.3	.....
Head length as percentage of body length	30.0–35.5	33.5	31.0–37.5	33.1	31.0–37.1	33.2
Femur length as percentage of body length	39.6–49.8	44.3	43.9–47.3	45.4	35.3–43.6	38.3
Tibia length as percentage of body length	46.7–53.9	50.7	48.2–52.0	50.3	34.9–49.9	46.2

leg length toward the south, table 24. Other trends in geographic variation are not evident.

Habits.—Except for a brief period in spring when it is mating, the gopher frog remains hidden in abandoned crayfish holes and is seldom encountered above ground. The distribution of this species is apparently correlated with the hardpan, clay soils that are extensive in southern Illinois. Outlier prairies, wet pastures, and golf courses are particularly favorable habitats. During summer and fall an adult can sometimes be found by investigating a large-bore crayfish hole that has a bare platform to one side of the entrance. The frog usually may be seen an inch or so below the surface, but when disturbed it backs down to the bottom of the burrow, where it wedges its body against the sides of the hole. The bottom of the burrow usually contains fecal matter, including

crayfish remains. The depth of the hole averages a little less than a yard.

The breeding season of this frog varies somewhat with temperature and the distribution of spring rains; choruses have been heard from early March to mid-April. The call of the male is a prolonged bass snore with remarkable carrying power. The preferred breeding sites are flooded fields, farm ponds, and small lakes in pastures or on golf courses; at the peak of the season several hundred adults may occupy a single pond. Approximately 5,000 eggs are deposited by each female in shallow water as large, submerged masses. Hatching probably requires several days. The larvae transform in Illinois in late June and early July.

Illinois Distribution.—The gopher frog, or northern crayfish frog, is a characteristic animal of the outlier prairies of the southern half of Illinois, fig. 81, and it is much more abundant than the map indicates. In Illinois the range of the species terminates abruptly at the southern edge of the Shelbyville Moraine; records for adjacent Indiana and Iowa extend slightly farther north.

Rana catesbeiana Shaw Bullfrog

Rana catesbeiana Shaw 1802:30 (type locality: South Carolina; revised to vicinity of Charleston by Schmidt 1953); Shelford 1913:171.

Rana catesbeiana, Yarrow 1882a:184.

Rana catesbeiana, Hankinson 1915:294.

Rana pipiens nec Schreber, Brendel 1857:254.

?*Rana clamitans* nec Latreille, Hankinson 1910:25.

Diagnosis.—A large *Rana* (largest Illinois specimen 154 mm. from snout to vent), fig. 82, lacking dorsolateral folds but possessing well-developed tympanic folds; webbing extending to toe tips; olive, green, or brown dorsum, with dots or obscure blotches but not with discrete dark spots; median gular vocal pouch in the male; and tympanum larger than eye in adults of both sexes.

Variation.—The male bullfrog differs from the female in being smaller in size and in having greatly enlarged tympanums, swollen thumbs, yellow throat, and two openings inside the mouth which lead to the vocal pouch.

Virtually all juveniles less than 60 mm. in snout-vent length are olive, with small,

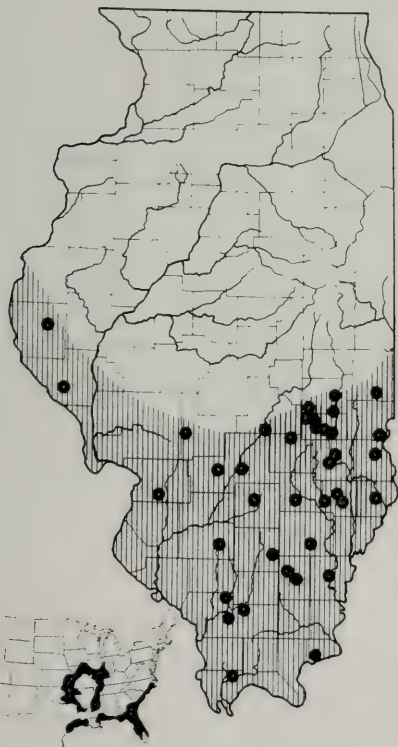


Fig. 81.—Distribution of *Rana areolata*. Hatching indicates the presumed range of the subspecies *circulosa* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

black, evenly distributed dots over the dorsum. The dots are retained in occasional adults but they are usually brown rather than black. In most large subadults the dark dots are lost and the pattern, if present at all, consists of mottling or light, obscure blotches on a darker groundcolor. Sexual dimorphism is not evident in juveniles.

The range of individual variation in pattern and proportions in a single sample usu-

Half of the specimens available are reticulated or spotted ventrally; the highest frequency of such frogs occurs in western Illinois and the lowest frequency in eastern Illinois. This character is probably of little significance.

Habits.—The bullfrog inhabits almost any type of permanent water, such as lake, pond, river, and creek. Adults are rather solitary, each frog occupying part of the



Fig. 82.—An adult *Rana catesbeiana* from Coles County, Illinois. The color range is usually olive or brown over the body, with some green on the upper jaw.

ally exceeds any geographic variation discernible. The mean tibia length in samples of 12 to 20 specimens from Shawnee Hills, south-central Illinois, and north-central Illinois varies from 48.5 to 49.3 per cent of the body length, exhibiting a difference of less than 1.0 per cent. A series of 20 specimens from western Illinois differs only slightly, averaging 47.5 per cent. The lower mean, which is of doubtful significance, is due to nine specimens, from Adams and Hancock counties, that are somewhat shorter-legged.

stream or pond to the exclusion of other adults. They are wary and are difficult to approach during the day but rather easy to catch at night. When disturbed they retreat to deeper water with a series of long leaps and considerable splashing. The bullfrog is of some importance as food for man. However, in parts of Illinois the gopher frog is eaten by more people. The bullfrog is voracious, eating almost any animal it can swallow. Although a great many kinds of animals have been found in bullfrog stomachs,

crustaceans and insects probably make up the bulk of the diet.

Breeding in the bullfrog occurs from late April until August. The call of the male is a deep bass, consisting of two slurred syllables. The song, which has great carrying power, has been characterized as "jug-o'-rum" and "br-wum." Each female lays several thousand eggs in a huge surface mass, often a yard across. Hatching occurs in less than a week. Although tadpoles grow rapidly, they presumably overwinter, developing legs the following spring, and metamorphose in July and August of their second season. The larvae may attain a length of more than 6 inches.

Illinois Distribution.—The bullfrog is common in all parts of Illinois, fig. 83.

Although undocumented by specimens, published records for the following locali-

ties are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Evanston (Schmidt & Necker 1935); Willow Springs (Schmidt 1929); DU PAGE COUNTY: Naperville (Necker 1939c); JACKSON COUNTY: Carbondale (Cagle 1942a); 2 mi. S Elkhartville (Burt & Burt 1929); LAKE COUNTY: Waukegan (Schmidt 1929); McHENRY COUNTY: McHenry (Necker 1939c); MACOUPIN COUNTY: Standard City (Owens 1941); MADISON COUNTY: opposite St. Louis (Hurter 1893); MORGAN COUNTY: Meredosia (Weed 1923); PEORIA COUNTY: Peoria (H. Garman 1892); UNION COUNTY: Anna (H. Garman 1892); 7 mi. S Anna (Burt & Burt 1929); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WASHINGTON COUNTY: 7 mi. SE Beaucoup, Nashville (Burt & Burt 1929).

Rana clamitans melanota (Rafinesque)
Green Frog

Ranaria melanota Rafinesque 1820:5 (type locality: Lake Champlain, New York).

Rana clamitans melanota, Meham 1954:1, 4, 5, 9.

Rana clamata, Kennicott 1855:593.

Rana clamitans, Yarrow 1882a:183.

Diagnosis.—A medium-sized to large *Rana* (largest Illinois specimen 95 mm. from snout to vent), fig. 84, with prominent dorsolateral folds that extend only to the middle of the back; webbing extending almost to the toe tips; back olive, brown, or green; dorsum plain, or with obscure dark spots which are not light margined; dark spots or reticulations usually on chin, breast, and undersides of legs; sexual dimorphism (in color and size of tympanum) pronounced.

Variation.—In *Rana clamitans melanota* the male differs from the female in having a larger tympanum, swollen thumbs, and stouter forelegs. In most of Illinois, it has a bright green upper jaw and yellow throat; the population in extreme southern Illinois is exceptional in that color dimorphism is less pronounced. The female is said to be larger than the male; this size difference is not obvious in the series at hand, although the largest specimen known is a female.

Ontogenetic variation is not striking, but the ventral markings are somewhat bolder in subadults than in large frogs.

In most of Illinois geographic variation in the green frog is rather slight. A weak



Fig. 83.—Distribution of *Rana catesbeiana*. The species occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.



Fig. 84.—An adult *Rana clamitans melanota* from Vermilion County, Illinois. The ground-color is green, olive, or brown. Males usually have green upper jaws and yellow throats.

Table 25.—Geographic variation in Illinois *Rana clamitans*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHERN ILLINOIS (39)		WESTERN ILLINOIS (13)		EASTERN ILLINOIS (11)		EXTREME SOUTHERN ILLINOIS (18)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Femur length as percentage of body length.....	43.2-53.9	48.3	44.2-51.2	48.3	45.2-54.2	49.9	46.1-53.3	48.5
Tibia length as percentage of body length.....	45.3-54.5	50.2	46.6-54.5	50.4	47.0-54.3	52.1	46.3-54.1	51.2
Snout-vent length (mm.), maximum.	95.0	.....	77.0	.....	84.0	.....	79.0	.....
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With belly unmarked	69.0		84.5		82.0		33.5	

trend toward greater average size and better-developed dorsal spotting in the northern samples is apparent. In the samples from the southwestern tip of the state the individuals are of smaller average size; frequent specimens are without dorsal spotting; and many have dark markings on the belly, some being boldly marbled with black. The males tend to have dusky upper jaws and throats rather than the green and yellow of more northern males. The southwestern samples are assumed to represent an intergrade population, *R. c. melanota* $\times$ *clamitans*. The variation is illustrated by four samples, table 25.

Habits.—In northern Illinois the green frog occurs in a variety of aquatic habitats, but in the central and southern counties it appears to be restricted to clear streams in the vicinity of rock outcrops. It is often seen on a bank above water and when disturbed it can reach the safety of deep water with a single leap. A startled green frog sometimes emits a high-pitched squawk at the instant it jumps. Like the bullfrog, this species is somewhat solitary in habits, but the presumed home range of one individual is smaller in area than that of the bullfrog. The green frog probably eats almost any invertebrate and small vertebrate animal on occasion, but the chief items in its diet are arthropods, mollusks, and annelids.

In Illinois breeding of the green frog apparently occurs throughout the summer, as singing may be heard from May until September. The call of the male consists of two or three well-spaced, explosive notes, each of which closely resembles the plucking of the bass string on a banjo. The female deposits several thousand eggs in shallow surface masses that are similar to those of the bullfrog, but each mass is less in diameter. Hatching occurs in a few days. The tadpoles, which resemble the bullfrog larvae, overwinter and transform throughout the summer of the second season.

Illinois Distribution.—The Illinois distribution, fig. 85, of the green frog, which is abundant in most of eastern North America, is puzzling. The species is common in ponds, lakes, and streams throughout the northern fourth of the state, but it becomes increasingly sporadic in occurrence to the south. In central and southern Illinois it is absent from the Grand Prairie and the Southern Division, but it occurs along both

the extreme eastern and western edges of the state in the immediate vicinity of rock outcrops. In the Shawnee Hills of southern Illinois it is common in rocky, clear streams. The record for Charleston (Hankinson 1910) is almost certainly based on a misidentified specimen of the bullfrog.

Intergradation of *R. c. melanota* with *R. c. clamitans* occurs along the Mississippi River floodplain of Jackson, Union, Alexander, and possibly Johnson counties. The swampy habitat of the intergrade population is quite different from the preferred habitat of the northern *R. c. melanota* and resembles that of *R. c. clamitans*.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on



Fig. 85.—Distribution of *Rana clamitans*. Vertical hatching indicates the presumed range of the subspecies *melanota* in Illinois; cross-hatching, the presumed range of the *melanota* $\times$ *clamitans* intergrades; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

the distribution map by hollow symbols: CHAMPAIGN COUNTY: Champaign (H. Garman 1892); COOK COUNTY: Chicago (Schmidt & Necker 1935); DU PAGE COUNTY: Naperville (Schmidt & Necker 1935); JACKSON COUNTY: 4 mi. S Carbondale (Burt & Burt 1929); KANE COUNTY: Batavia, West Dundee (Stille & Edgren 1948); LAKE COUNTY: Fox Lake (Schmidt & Necker 1935); McHENRY COUNTY: McHenry, Richmond (Schmidt & Necker 1935); UNION COUNTY: 7 mi. S Anna (Burt & Burt 1929); WILL COUNTY: Hickory Creek (Necker 1939c); Marley, New Lenox (Schmidt & Necker 1935); Romeo-ville (Necker 1939c).

Rana palustris Le Conte
Pickerel Frog

Rana palustris Le Conte 1825:282 (type locality: not given; suggested as vicinity of Philadelphia, Pennsylvania, by Schmidt 1953); Brendel 1857:254.

Diagnosis.—A small to medium-sized *Rana* (largest Illinois specimen 69.2 mm.

from snout to vent), fig. 86, with distinct, square or rectangular, brown or black blotches arranged in two more or less regular series between the dorsolateral folds; dorsolateral folds yellow, extending to the hip region, and approximately half the width of the dorsal blotches; groundcolor gray or tan; concealed surfaces of hind legs and often the belly with a wash of bright yellow.

Variation.—The male pickerel frog has enlarged thumbs, each of which bears a small pad on its inner surface. According to Pope (1944b), the male is usually darker, larger, and more fully webbed between the toes than the female. In our series, however, the female averages larger, and Walker (1946) noted that females are larger in Ohio specimens.

No small specimens are available for study. Young frogs observed in the field, however, seemed to differ from adults in their proportionately larger heads and smaller legs.

Two races of the pickerel frog, differing in pattern details and proportions, are present in Illinois: an unnamed race, which oc-

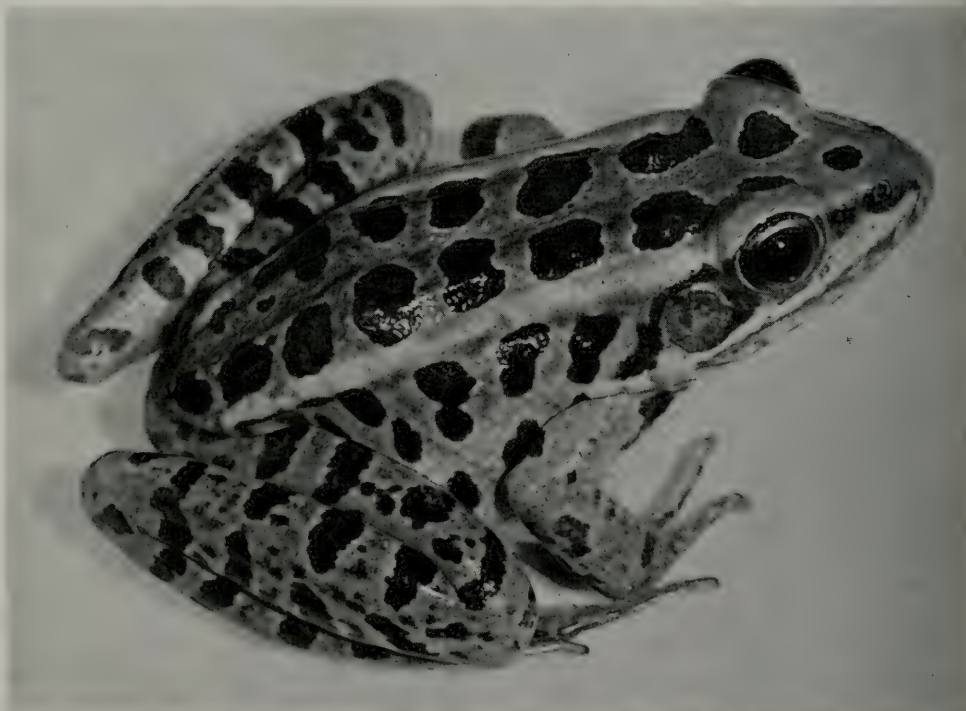


Fig. 86.—An adult *Rana palustris* from Monroe County, Illinois. The groundcolor is yellow, tan, or light gray; the square or quadrangular blotches are chestnut or dark brown.

Table 26.—Geographic variation in Illinois *Rana palustris*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	ALEXANDER- UNION COUNTIES (8)		MONROE COUNTY (17)		PIKE, ADAMS, AND GREENE COUNTIES (23)		NORTHERN ILLINOIS (11)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Snout-vent length..	28.2-57.0	.....	33.0-64.8	.....	34.5-69.2	.....	34.5-56.0	.....
Head length as per- centage of body length.....	35.6-41.2	38.0	33.9-38.8	36.8	32.1-38.6	36.1	33.0-38.4	36.0
Tibia length as per- centage of body length.....	51.0-55.3	53.5	50.2-62.5	56.9	54.2-62.9	57.6	55.6-63.5	58.7
Blotches between dermal folds.....	6-15	9.9	11-17	13.8	9-21	15.1	6-17	12.7
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With snout spot. ...	12.0		77.0		84.3		82.0	
With mottled chin..	88.0		70.6		21.9		9.0	
With mottling on underside of legs..	100.0		53.0		17.3		0	

curs in Alexander and Union counties and occupies an unexpected habitat for the species, and the typical race, which occurs sporadically along the rock bluffs of the Mississippi River northward to the northern fifth of the state, where it is rather general in occurrence. The two races differ slightly in proportions and markedly in pattern, table 26.

Habits.—Throughout most of its range this frog is limited in distribution by its intolerance of bodies of water that are both warm and sluggish. In northern Illinois, for example, the species occurs around ponds, creeks, and marshes, and in central Illinois it is found only in cold springs or rocky, fast-running streams. In western Illinois the species exhibits a fondness for caves in which there are permanent streams. However, in southern Illinois a race of the pickerel frog occurs in the relatively warm waters of floodplain swamps. Pickerel frogs are alert and powerful jumpers and accordingly difficult to collect in marsh or stream-edge vegetation. The pickerel frog is reputed to have a skin secretion that is toxic or at least distasteful to many other animals, but experimental evidence is needed to substantiate the report. Its food consists probably of arthropods and mollusks.

The pickerel frog presumably spawns in the clear, quiet water of bogs, lakes, and ox-bows. The song of the male is a short, low-pitched snore with little carrying power. The female lays 1,000 to 2,000 eggs in compact globular masses. The eggs hatch in about 2 weeks. I have not seen tadpoles in Illinois. Newly transformed adults are found the last of June.

Illinois Distribution.—The peculiar distributional pattern of this species, fig. 87, has been noted above. The range to some extent parallels that of *R. clamitans*, but the pickerel frog seems even less tolerant of conditions in the central prairie region. Although records are available from west-central Indiana, the Illinois range of the species is probably little more extensive than the localities on the map indicate. There is some possibility, however, that it may be found in the dissected canyons of La Salle County and in the rocky streams of extreme eastern Clark and Vermilion counties.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: KANE COUNTY: Batavia (Stille & Edgren 1948); ST. CLAIR COUNTY: Bluff Lake (Hurter 1893).



Fig. 87.—Distribution of *Rana palustris*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Rana pipiens Schreber Leopard Frog

Opinion is about equally divided among current herpetologists as to whether *Rana pipiens* consists of subspecies distinct enough to warrant taxonomic recognition. Inasmuch as this is one of the most famous problems in herpetological taxonomy, a solution satisfactory to everyone will appear only when series of specimens from over all of North America are studied in monographic fashion. In spite of the difficulty in recognizing races in some parts of the continent, there are certain geographical areas in which the distinctness of subspecies is unavoidable. Such is the case in Illinois and adjacent states, and it is as difficult to lump the two Illinois populations of the leopard frog as

it seems to be for eastern and southwestern investigators to recognize more than one form of this frog. Variation data for the Illinois populations are presented in the hope that they may contribute to a final understanding of the *pipiens* problem.

Unfortunately, the question of names for the population adds still more confusion, and usage of *pipiens* and *sphenocephala* as subspecific names for the two Illinois populations is accordingly tentative. The names involved in eastern North America are *pipiens* (1782, type locality: New York), *brachycephala* (1889, type locality: Yellowstone River), *sphenocephala* (1886, type locality: St. John's River, Florida), and *berlandieri* (1854, type locality: South Texas). Provisional assignment of the subspecific name *pipiens* to the northern Illinois frogs and the subspecific name *sphenocephala* to the southern Illinois frogs assumes that the populations *berlandieri* and *sphenocephala* are distinct taxonomically. Otherwise, the earlier name, *berlandieri*, would supersede *sphenocephala* for the southern population. Assignment of the name *pipiens* to the northern population also assumes that the names *pipiens* and *brachycephala* refer to the same population, or that *pipiens* Schreber is an intergrade between the northern, large spotted frog that Cope described as *brachycephala* and the southern, small spotted frog that the same author described as *sphenocephala*. This assumption (that *pipiens* is an intergrade between the northern and southern races) is a strong possibility, although Schreber's colored plate represents a fairly typical specimen of the northern frog; and, if correct, the name *pipiens*, which has priority over both *sphenocephala* and *brachycephala*, could be assigned to either of these races. Obviously, it would be preferable to restrict *pipiens* to the northern form, in view of the long usage of the name in experimental biology for frogs from the northern population.

In brief, the history of the *pipiens* investigations is as follows. Cope (1889) assigned *sphenocephala*, *brachycephala*, and *virescens* to *R. virescens* (equals *pipiens*) as subspecies. Dickerson (1906) and the Wrights (1933 to date) recognized *pipiens* and *sphenocephala* as races of *R. pipiens*, but they did not accept *brachycephala*. Boulenger (1920) regarded *R. pipiens* as a monotypic species. Kauffeld (1936) resurrected

brachycephala and regarded it, as well as *pipiens* and *sphenocephala*, as full species. Mittleman & Gier (1942) resurrected *berlandieri* for the southwestern leopard frogs, but evaded the question of the validity of other races. Moore (1944), who studied the problem most intensively, concluded that no subspecies were recognizable.

Cope (1889) and Kauffeld (1936) both utilized proportionate head length as a criterion for separating the three races which they recognized, and Dickerson (1906) and the Wrights (1933) used the same character for distinguishing *pipiens* from *sphenocephala*. Trapido & Clausen (1938) and Grant (1941) criticized the use of this character because Quebec specimens under study by them failed to agree with the proportions Kauffeld (1936) recorded for *brachycephala* (the population presumably occurring in Quebec). Moore (1944) tested this character with large series and reported no significant differences in head proportions. These seemingly diametrically opposite views are easily explained if samples of similar-sized specimens are compared. The amount of ontogenetic variation in proportionate head length in one population exceeds the amount of variation displayed by adults of the two different populations. The difference in means between samples of similar-sized individuals from the two populations is slight. The northern population, *brachycephala* of Kauffeld or *pipiens* as here understood, attains a larger maximum and average size, however, and, if small samples of fully adult specimens of northern and southern frogs are compared, the difference between the means is magnified simply because the northern form is a larger frog. It is likely that Cope and Kauffeld believed the head-length character was diagnostic for this reason. Actually, it has only limited diagnostic value, but it is discernible. The ratios displayed by 64 specimens of *R. p. pipiens* from northern Illinois and 60 specimens of *R. p. sphenocephala* from southern Illinois are shown by the graph, fig. 88.

Length of snout, as well as proportionate head length, has been used as a subspecific character by those authors who recognize subspecies in *R. pipiens*. In the Illinois series the southern frogs appear to have longer, more acuminate snouts, but I am unable to find any mensurable difference. It appears that the position of the eyes and the more

prominent dark vitta of southern specimens creates the illusion of longer snouts.

Leg length has similarly been used as a subspecific character and it is usually expressed as the point reached by the heels when the legs are carried alongside the body. Because of the difficulty of manipulating limbs of preserved specimens, tibia/body ratios have been computed in lieu of the leg-body relationship. Moore (1944) investi-

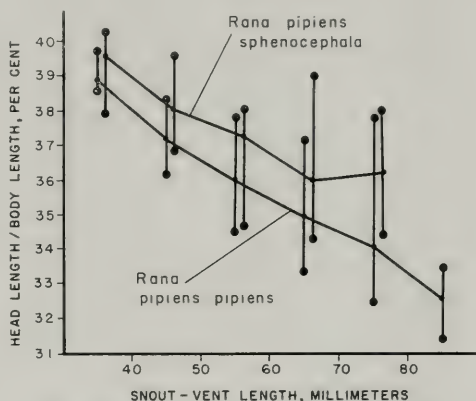


Fig. 88.—Head/body length ratios for 60 specimens of *Rana pipiens sphenocephala* and 64 specimens of *Rana pipiens pipiens*. The diagonal lines connect means of each size class; the vertical lines represent variational ranges exhibited by each size class.

gated both ratios and found only a slight tendency toward longer legs in those frogs from southeastern United States. Tibia/body ratios for 270 Illinois specimens reveal no indication of clinal variation in this character. In combined samples of *R. p. sphenocephala* the tibia averages 56.8 per cent of the body length, and in combined samples of *R. p. pipiens* it averages 56.9 per cent.

The degree of webbing, amount of dark mottling on the rear of the thighs, nature of the tibial bars, width of the dorsolateral folds, and presence of secondary dorsal ridges are of limited value, although none is constant enough to be a good diagnostic character.

The presence of a light tympanic spot, a character frequently stated to be diagnostic of *R. p. sphenocephala*, does not coincide geographically with the other subspecific characters of *R. p. sphenocephala* in Illinois. Instead, it occurs in all Illinois populations except those in the northern third of the state.

The remaining characters used by various authors (nature of vocal sacs in breeding males, size of spots and prominence of light margins, and groundcolor) and the presence of a dark snout spot are reliable; they indicate that two subspecies are valid.

***Rana pipiens pipiens* Schreber**
Northern Leopard Frog

Rana pipiens Schreber 1782:185, pl. 4 (type locality: New York; revised to White Plains, New York, by Schmidt 1953); H. Garman 1890:188-9 (part).

Rana pipiens pipiens, Pope 1944b:132-42.

Rana halecina, Kennicott 1855:593.

Rana halecina halecina, Davis & Rice 1883a:28 (part).

Rana halecina berlandieri nec Baird, ?Yarrow 1882a:181.

Rana virescens, H. Garman 1889:134.

Rana virescens virescens, Cope 1889:403 (part).

Rana virescens brachycephala Cope 1889:403-6 (type locality: Yellowstone River).

Rana pipiens brachycephala, Wright & Wright 1949:511.

Rana utricularia, H. Garman 1892:321-2 (part).

Rana pipiens burnsi, Wright & Wright 1933:178-9.

Rana pipiens sphenoccephala nec Cope, Wright & Wright 1949:496-7 (part).

Diagnosis.—A medium to large *Rana* (largest Illinois specimen 96.2 mm. from snout to vent), fig. 89, with large subround or elongate dark spots on a green, tan, or brown background; venter white or off-white; a pair of prominently widened dorsolateral folds extending the length of the back; secondary ridges often present between dorsolateral folds; the breeding male with a pair of lateral vocal pouches that do not project posteriorly; a large dark spot on top of snout (in 87 per cent of specimens); dorsal spots distinctly margined with light and averaging larger than eye (in 78 per cent of specimens); no discrete light spot in center of tympanum; postfemoral reticulum heavy; tibia boldly barred with dark.

Variation.—The male leopard frog is smaller than the female and differs also in having enlarged thumbs and stouter fore legs. During the breeding season, the skin is loose between the angle of the jaws and the shoulder region, indicating the position of the internal vocal sacs of the male frog.

Juveniles have proportionately longer, narrower heads than adults and weaker

bars across the legs. The head-length relationship is graphed in fig. 88.

Several trends of unknown importance can be discerned by comparing series of specimens from northeastern Illinois with those from northwestern Illinois. Specimens from the northeast tend to possess a darker groundcolor, more conspicuous light margins around spots, larger spots, and more prominent secondary dermal ridges between the dorsolateral folds.

In Illinois, the most striking geographic variation in *R. pipiens pipiens* occurs from north to south, inasmuch as *pipiens* intergrades with *R. p. sphenoccephala* in the central part of the state. Two intergrade samples, one from Coles County and the other from Mason and Morgan counties, differ from northern Illinois leopard frogs in the smaller frequency of individuals with snout spots, the smaller average size of the dorsal spots, the occasional presence of males with external vocal sacs, and the usual presence of a light tympanic spot. These characteristics for four typical *pipiens* samples and two intergrade samples are shown in table 27.

Habits.—The leopard frog occurs in abundance in the vicinity of streams, ponds, or lakes and it is frequently encountered in fields well away from permanent water. It is an excellent jumper and is so alert that it is difficult to capture unless it is stalked at night with a flashlight. The captured frog often squawks and usually emits a copious quantity of urine. When seized by a predator, such as a snake, the leopard frog may scream. Juveniles of this species sometimes inhabit puddles—water-filled automobile tracks—in little-used dirt roads. The heads of several young frogs may be seen protruding from the water by any person approaching such a puddle. As soon as the young frogs sense danger, they quickly leave the water for the greater protection of surrounding vegetation.

Breeding in the northern leopard frog occurs from mid-March to May. The breeding sites are ponds, lakes, sloughs, or semi-permanently flooded fields. The call of the male has been characterized as "coaxing" and can be simulated by rubbing a thumb over an inflated balloon. Each female deposits 3,000 to 5,000 eggs in compact, slightly flattened, submerged spheres, which are usually 3 to 6 inches across. Hatching presumably requires approximately a week, and



Fig. 89.—An adult *Rana pipiens pipiens* from Porter County, Indiana. The groundcolor may be green, gray, or tan; the spots are usually brown. Note spot on snout. (Photo by Isabelle Hunt Conant.)

Table 27.—Geographic variation in Illinois *Rana pipiens pipiens* and *R. p. pipiens* × *sphenocephala* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTH- EASTERN ILLINOIS (18)	NORTH- WESTERN ILLINOIS (23)	HENDER- SON- WARREN COUNTIES (14)	CHAM- PAIGN- VERMILION COUNTIES (9)	COLES COUNTY (20)	MASON- MORGAN COUNTIES (24)
With snout spot (per cent of specimens) . . .	89.0	78.0	72.0	84.0	45.0	33.0
With average dorsal spot smaller than eye (per cent of specimens)	0	0	0	22.0	40.0	71.0
With external vocal sac (per cent of males)	0	0	0	0	28.5	36.0
Snout-vent length (mm.), maximum . . .	77.8	88.9	72.0	84.0	96.2	84.0

transformation occurs from June until August.

Illinois Distribution.—*R. p. pipiens* is common around almost all types of water throughout the northern half of Illinois, fig. 90. Intergradation with *R. p. sphenoccephala*

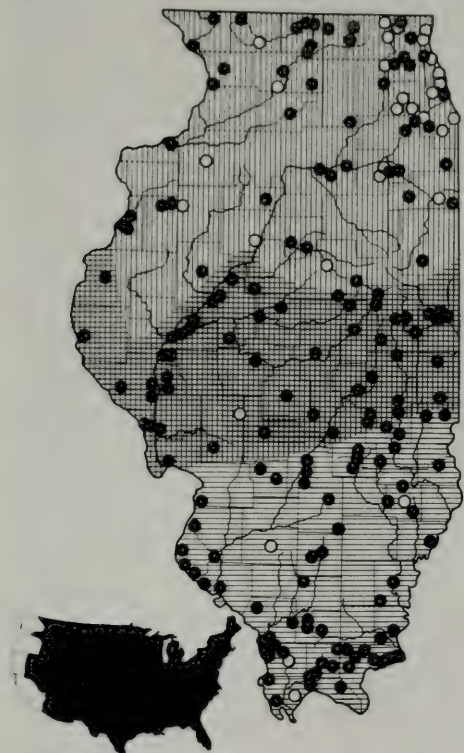


Fig. 90.—Distribution of *Rana pipiens*. Vertical hatching indicates the presumed range of the subspecies *pipiens*; horizontal hatching, the presumed range of the subspecies *sphenoccephala*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

cephala occurs across the central part of the state. The intergrading area is relatively narrow in eastern Illinois, wider along the Mississippi River, and also wider in the Illinois River valley, where intermediates are known from Jersey to Mason County.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols:

COOK COUNTY: Carle Woods (Necker 1939c); Chicago Ridge (Schmidt & Necker 1935); Deer Grove, Evanston (Necker 1939c); Homewood, Lambert, Wolf Lake (Schmidt & Necker 1935); DU PAGE COUNTY: Downers Grove, Glen Ellyn, Lisle, Naperville (Schmidt & Necker 1935); GRUNDY COUNTY: Coal City, Pequot (Necker 1939c); HENRY COUNTY: (H. Garman 1892); KANE COUNTY: West Dundee (Stille & Edgren 1948); KANKAKEE COUNTY: Aroma Township, Pembroke Township (Schmidt & Necker 1935); KNOX COUNTY: 2½ mi. E Galesburg (Adcock 1922); LAKE COUNTY: Beach, Fox Lake, Highland Park (Schmidt & Necker 1935); Waukegan (Necker 1939c); McHENRY COUNTY: McHenry, Richmond (Schmidt & Necker 1935); McLEAN COUNTY: Normal (H. Garman 1892); OGLE COUNTY: Grand Detour (Yarrow 1882a); PEORIA COUNTY: Peoria (H. Garman 1892); STEPHENSON COUNTY: Freeport (H. Garman 1892).

Rana pipiens sphenoccephala Cope Southern Leopard Frog

Rana halecina sphenoccephala Cope 1886:517 (type locality: near St. John's River, Florida).

Rana sphenoccephala, Blanchard 1924b:535.

Rana pipiens sphenoccephala, Wright & Wright 1949:496-7 (part).

Rana halecina halecina, Yarrow 1882a:179-80.

Rana halecina, Boulenger 1920:433-45 (part).

Rana virescens virescens, Cope 1889:403 (part).

Rana virescens brachycephala nec Cope, Cope 1889:405-6 (part).

Rana pipiens, H. Garman 1890:188-9 (part).

Rana pipiens pipiens nec Schreber, P. W. Smith 1947:32.

Rana utricularia, H. Garman 1892:321-2 (?part).

Diagnosis.—A subspecies of *Rana pipiens* (largest Illinois specimen 79.4 mm. from snout to vent), fig. 91, differing from *R. p. pipiens* in being smaller, in lacking a dark snout spot, and in having the following additional characters: a pair of external vocal sacs which project posteriorly in the breeding male; dorsal spots averaging smaller than eye diameter (in 76 per cent of specimens); dorsal spots not distinctly margined with light; groundcolor light tan, gray-green, or light brown; usually a discrete light spot in center of tympanum; tibial bars frequently interrupted; less distinct postfemoral re-



Fig. 91.—An adult *Rana pipiens spenocephala* from Union County, Illinois. The ground-color is usually gray or tan, rarely green; the spots are brown.

ticulum; narrower and lighter colored dorsolateral folds; narrower and lighter colored maxillary ridge; and sharper-appearing snout.

Variation.—Sexual variation in *R. p. spenocephala* is similar to that in *R. p.*

pipiens, although more pronounced because of the pouchlike vocal vesicles, the statement by Liu (1935) that all *pipiens* subspecies have internal sacs notwithstanding.

Ontogenetic variation in the southern leopard frog is similar to that in the northern

Table 28.—Geographic variation in Illinois *Rana pipiens spenocephala*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (20)		SHAWNEE HILLS (20)		SOUTH-CENTRAL ILLINOIS (20)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.), maximum.....	79.4	.....	78.2	.....	66.0	.....
Spots between dorsolateral folds.....	5-20	12.8	8-30	17.3	7-23	14.5
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With snout spot.....	5		15		10	
With tympanic spot.....	80		85		95	

subspecies. The head-length/body-length relationships are summarized in fig. 88.

Individual variation in a series of *R. p. sphenocephala* from one locality exceeds geographic variation (the difference between series) displayed within Illinois. The only trend discerned in this subspecies is a tendency for individuals from the Mississippi and Ohio River floodplains at the southern tip of Illinois to have fewer dorsal spots. These frogs are usually brassy in appearance, and a few individuals have been seen that had no dorsal spots. Such individuals are remarkably similar to wood frogs. Variation in the more salient features of three samples of *R. p. sphenocephala* is summarized in table 28.

Habits.—The southern leopard frog is similar to the northern race in habits and habitat, and most of the remarks concerning behavior of *R. p. pipiens* apply as well to this form. The breeding season for *sphenocephala* is known to be earlier, and singing begins in early March and extends into April. There is some likelihood that development is faster in *sphenocephala*; transforming frogs can be found in June and early July.

Illinois Distribution.—The southern leopard frog is abundant throughout the southern half of Illinois, fig. 90. Intergradation with *R. p. pipiens* occurs in a rather narrow zone in eastern Illinois at about the Shelbyville Moraine. The intergrading area widens in western Illinois, but it usually does not exceed a hundred miles in width.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: MACOUPIN COUNTY: Standard City (Owens 1941); PULASKI COUNTY: Villa Ridge (H. Garman 1892); RICHLAND COUNTY: Olney (Cope 1889); UNION COUNTY: Anna (H. Garman 1892); 2 mi. N Anna (Burt & Burt 1929); WASHINGTON COUNTY: (Yarrow 1882a).

Rana sylvatica Le Conte

The wood frog is transcontinental in northern North America. Several allied populations of northern Europe and Asia belong to the same complex but are currently considered to be specifically distinct. The North American wood frog has been gener-

ally regarded as consisting of three subspecies; the distributional limits and the diagnostic characters, until quite recently, have been vaguely defined in the herpetological literature. The species has, however, just received an intensive and thorough revision by Martof & Humphries (1959), who suggest that the named subspecies be dropped. Their analysis of geographic variation in the species is excellent and objective; their taxonomic recommendation, in my opinion, is prompted by their personal attitude toward subspecies. Inasmuch as their data can be interpreted as suggesting that races are recognizable, subspecific names are provisionally retained for the two types of wood frogs represented in Illinois.

Rana sylvatica sylvatica Le Conte Eastern Wood Frog

Rana sylvatica Le Conte 1825:282 (type locality: not stated; designated as New York City by Schmidt 1953); Shelford 1913:195, 206, 243, 244, 256.

Rana sylvatica sylvatica, Cagle 1941:9 (part).

Rana silvatica, Brendel 1857:254.

Rana temporaria silvatica, Yarrow 1882a:185 (part).

Rana cantabrigensis nec Baird, Hay 1892a:586.

Rana cantabrigensis cantabrigensis nec Baird, Cope 1889:437.

Rana sylvatica cantabrigensis nec Baird, Schmidt 1938a:379 (part).

Diagnosis.—A medium-sized *Rana* (largest Illinois specimen 54.5 mm. from snout to vent), fig. 92, with prominent dorsolateral folds; tympanum smaller than eye; two or three joints of fourth toe free of webbing; tan or rich red-brown groundcolor above, with a conspicuous chestnut or black mark on each side of head; dark dash on shoulder; tibia 55 per cent or more of snout-vent length; head 33 per cent or more of snout-vent length; breast plain white (64 per cent of specimens); dorsum immaculate or occasionally with scattered small black dots but without longitudinal light or dark stripes between dorsolateral folds; secondary ridges between dorsolateral folds seldom present.

Variation.—No average size difference in the sexes is evident in the Illinois series of eastern wood frogs. The male possesses swollen thumbs, each of which bears a small pad on the inner surface, and somewhat stouter front legs; and the webbing between the toes of the hind feet is convex rather



Fig. 92.—An adult *Rana sylvatica sylvatica* from Clark County, Illinois. The groundcolor is tan or light red-brown; the mask through the face and dorsal flecks are chestnut or dark brown.

than incised. In the breeding ponds the female may be rich red-brown while the male may be almost black. Outside the breeding ponds individuals of both sexes are ordinarily light in color, but the female is usually the more brightly colored.

Table 29.—Geographic variation in Illinois *Rana sylvatica sylvatica* and *R. s. sylvatica* × *cantabrigensis* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHWESTERN ILLINOIS (6)		EAST-CENTRAL ILLINOIS (30)		NORTHEASTERN ILLINOIS (17)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.)	36.0–50.8	.....	34.8–54.5	.....	30.0–49.3	.....
Head length as percentage of body length	33.5–38.4	36.0	31.3–37.2	33.9	29.9–36.7	32.6
Tibia length as percentage of body length	58.3–63.0	61.1	51.4–61.8	58.6	49.8–59.5	54.0
Femur length as percentage of body length	47.3–56.9	51.4	48.8–56.6	52.9	44.2–54.3	50.5
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With breast unmarked	100.0		78.0		12.0	
With dark interorbital bar	83.0		0		24.0	

Young specimens are slightly shorter legged, larger headed, and less brightly colored than adults.

In Illinois the most noticeable trends in geographic variation are the proportionately greater head size and longer legs in samples from north to south. The limited data at hand thus conform in general with the findings of Schmidt (1938a) that there is a north-south cline in leg length in the wood frog. Although north-south clines are evident in the Illinois wood frogs, the data do not preclude the possibility that a northern and southern race are involved. Suzuki (1951) did not find a regular cline in tibial length in Wisconsin samples, and specimens at hand from Arkansas are no longer legged than specimens from southwestern Illinois. The population in northeastern Illinois is regarded as being composed of *R. s. sylvatica* $\times$ *cantabrigensis* intergrades. The sample from this part of Illinois displays *cantabrigensis* characters in proportionate head length, tibial length, size, and ventral pattern but *sylvatica* characters in dorsal pattern and dorsal skin texture. This variation is summarized in table 29.

Habits.—The wood frog, which is usually solitary in habits, is restricted to relatively mesic forests in which there are permanent or semipermanent pools. It is usually not abundant even in optimum habitat and is often overlooked because its colors blend so well with fallen leaves. Individuals are most often seen when they call attention to themselves by making a long, low leap. In spring and fall the wood frog may be aquatic, but it spends most of the summer well away from water. Its food consists of arthropods and mollusks.

The short breeding season of the wood frog occurs in March. A pond may be suddenly full of breeding individuals and a week or two later they may have completely disappeared. The call of the male consists of a series of five or six explosive clucking notes that have little carrying power. Each female lays 2,000 to 3,000 eggs, which soon become a submerged globular mass. Hatching requires only a few days, and the larvae grow rapidly. The tadpole is distinctive because of the labial formula of $\frac{3}{4}$, fig. 53. Transformation takes place in May and June.

Illinois Distribution.—The eastern wood frog is exceedingly sporadic in occurrence

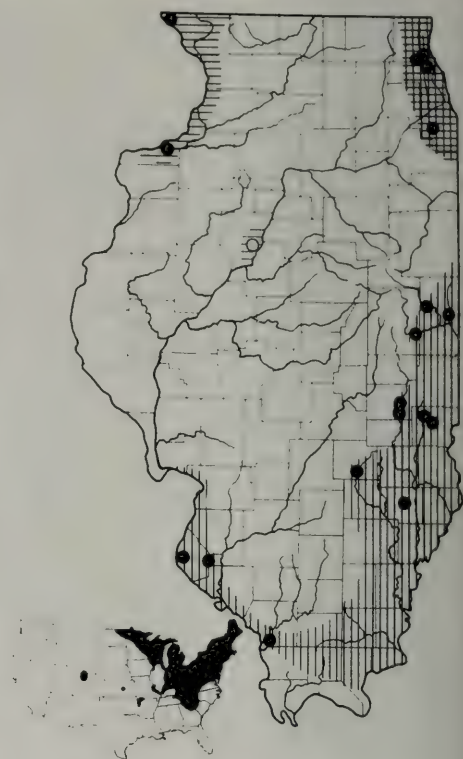


Fig. 93.—Distribution of *Rana sylvatica*. Vertical hatching indicates the presumed range of the subspecies *sylvatica* in Illinois; horizontal hatching, the presumed range of the subspecies *cantabrigensis*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

even in forested parts of the state, fig. 93. It is moderately common in Coles County, but attempts to find the species in some adjacent counties, which have seemingly suitable habitats, have been unsuccessful. Once a locality is found in which the species occurs, it is usually possible to collect specimens on each subsequent visit. It is difficult to ascertain if the number of wood frog populations has been appreciably reduced by drainage and destruction of forest or if this frog was sporadic in occurrence in Illinois even before such practices were begun. *R. sylvatica* is regarded as one of the animal indicators of the beech-maple forest, although most of the Illinois localities in

which the species is known are west of this ecological zone.

The wood frog populations throughout southern and most of eastern Illinois are regarded as typical *R. s. sylvatica*, the population in northeastern Illinois as *sylvatica* $\times$ *cantabrigensis* intergrades. The central prairie region is apparently uninhabited by the species.

***Rana sylvatica cantabrigensis* Baird**
Northern Wood Frog

Rana cantabrigensis Baird 1854a:62 (type locality: Cambridge, Massachusetts, in error; revised to Moose Jaw, Saskatchewan, by Schmidt 1953); Dickerson 1906:212.

Rana cantabrigensis cantabrigensis, Howe 1899:372.

Rana sylvatica cantabrigensis, Schmidt 1938a:379 (part).

Rana temporaria sylvatica nec Le Conte, Yarow 1882a:185 (part).

Rana sylvatica nec Le Conte, H. Garman 1892:330.

Rana sylvatica sylvatica nec Le Conte, Cagle 1941:9 (part).

Diagnosis.—A subspecies of *Rana sylvatica* (largest Illinois specimen 48.8 mm. from snout to vent), smaller than *R. s. sylvatica* and differing from it in having shorter legs (tibia less than 55 per cent of body length); proportionately shorter head (usually less than 33 per cent of the snout-vent length); usually spotted breast; frequently a dorsal pattern of dark, light, or both dark and light longitudinal stripes between the dorsolateral folds; and often raised ridges between the dorsolateral folds.

Variation.—Sexual dimorphism exhibited by *R. s. cantabrigensis* is the same as in *R. s. sylvatica*.

Suzuki (1951) mentions that the tibiae of immature Wisconsin wood frogs are proportionately shorter than those of adults. Juveniles are larger headed and less richly colored.

Five specimens from extreme northwestern Illinois vary as follows: snout-vent length 38.8 to 48.8 mm.; head length 30.5 to 35.6 (average 32.1) per cent of body length; tibia 52.4 to 55.8 (average 53.6) per cent of body length; femur 48.7 to 53.1 (average 50.2) per cent of body length; 80 per cent with spotted breasts; and 80 per cent with dark interorbital markings.

Habits.—The northern wood frog is similar to the eastern subspecies in habits, al-

though it shows somewhat greater ecological tolerance, inasmuch as it is sometimes found in open areas and along grassy stream borders (Pope 1944b). Its breeding season is somewhat later because of its more northern distribution.

Illinois Distribution.—*R. s. cantabrigensis* is known in Illinois by only five specimens, fig. 93. Very little field work has been done in northwestern Illinois early enough in the spring to encounter breeding wood frogs, but habitats that appear to be suitable for the species are fairly extensive. When more early spring collecting is done, this race may prove to be more general in occurrence. The specimens from Jo Daviess County deserve special comment. The collector reported that they were taken in a woodland pond near Galena, Illinois, but their general appearance strongly suggests a more northern provenance.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: PEORIA COUNTY: Peoria (H. Garman 1892).

MICROHYLIDAE

This large family contains two genera in the United States and numerous genera in the New World and Old World tropics.

Gastrophryne Fitzinger

Some authors believe that in the United States this genus contains a single polytypic species; others regard it as comprising two species, one consisting of several subspecies. One form enters southwestern Illinois.

Gastrophryne carolinensis carolinensis
(Holbrook)

Eastern Narrow-Mouthed Toad

Engystoma carolinense Holbrook 1836:83, pl. 11 (type locality: Charleston, South Carolina); Davis & Rice 1883a:27.

Gastrophryne carolinensis, Jordan 1929:226.

Microhyla carolinensis carolinensis, Hecht & Matalas 1946:5.

Microhyla carolinensis, P. W. Smith 1948:2.

Diagnosis.—A small, squat-bodied frog (largest Illinois specimen 33 mm. from snout to vent), fig. 94, without webbing between the toes and without a visible tym-



Fig. 94.—An adult *Gastrophryne carolinensis carolinensis* from Randolph County, Illinois. The groundcolor is olive, dark gray, rusty red-brown, or almost black.

panum; with a transverse fold of skin or a groove behind the head; head pointed, its width half or less than half the greatest body width, its length less than one-fourth the body length; dorsum red-brown, gray, or almost black, plain or irregularly blotched, with a tendency toward a median dark band that gradually widens posteriorly.

Variation.—During the breeding season of this toad the male differs from the female in having loose, discolored skin on the throat, but at other times specimens are extremely difficult to sex by external characters. The chin spinules noted on the male by Mittleman (1950) are not present on any of the Illinois frogs, although they are evident on a series of males from the Gulf Coast.

The immature frog differs from the adult in its proportionately wider head. The sides of the body in the juvenile are nearly parallel, whereas in the adult they diverge rapidly.

Two specimens from adjacent Missouri (Wayne County) are 37.2 and 37.6 mm. in

snout-vent length, thus exceeding the previously known maximum size (36.0 mm.) for this species. Fifteen Illinois specimens from Monroe and Randolph counties vary as follows: head width 25.6 to 32.8 (average 29.2) per cent of the snout-vent length; tibia 36.4 to 42.9 (average 39.0) per cent of snout-vent length; all are mottled ventrally, and almost half of them have lateroventral light markings between the front and hind legs. The dorsal pattern is variable, but all Illinois individuals have vague dorsolateral light bands.

Habits.—The eastern narrow-mouthed toad is a small frog, usually found in rotten stumps, or under flat rocks, bark, or other objects on the ground. Upon being uncovered, this frog appears dazed by light, but after an instant it darts away in a series of short, rapid hops. Occasionally two or three individuals may be found under one rock.

In the South the narrow-mouthed toad breeds throughout the summer. I have not found eggs or larvae of this toad in Illinois, but I have heard the low, nasal buzz of the

male near Valmeyer on two occasions, both in June. According to Wright & Wright (1949), each female produces approximately 850 eggs as small surface films, one layer deep, each layer composed of 10 to 90 eggs. The egg of this species is unique among Illinois amphibians in that it has a flat surface rather than being perfectly spherical. Hatching occurs in a few days, and transformation is said to occur in 20 to 70 days. The tadpole is unique inasmuch as it has a sucking disc rather than labial teeth, mandibles, and oral papillae.

Illinois Distribution.—The eastern narrow-mouthed toad has been assumed to occur in Illinois since Davis & Rice (1883a) published the first check list of Illinois amphibians and reptiles, but no specimens were secured until 1948. Since a number of collectors had attempted unsuccessfully to find the species in the southern tip of the state,

it was with some surprise that I discovered a colony of narrow-mouthed toads within 35 miles of St. Louis, fig. 95. Systematic collecting, aimed at extending the known range of the species, has shown it to be common along the Mississippi River bluffs of Monroe and Randolph counties but has revealed no greater range than this. Its range in adjacent Missouri is poorly known.

Shortly after the discovery of *Gastrophryne* in Illinois, a specimen was recorded from southeastern Iowa (Klimstra 1950). The apparently disjunct range of the species suggests that this frog was formerly widespread in occurrence and that some adverse environmental conditions, presumably lower temperatures, have reduced the range to relict colonies in the Mississippi River valley. It appears unlikely that the species has simply been overlooked in the intervening areas, since it is ordinarily easily collected and could scarcely have been missed in such well-known areas as Reelfoot Lake, Tennessee, and extreme southern Illinois.

Class REPTILIA

Turtles, Lizards, and Snakes

It is believed that reptiles were derived from Labyrinthodontia amphibians in the Pennsylvanian age. Although the primitive reptiles shared many similarities with certain extinct amphibian groups, reptiles as a class apparently appeared in an explosive evolutionary burst, flourished in great variety throughout the Mesozoic Age, and diminished with the appearance in the Cenozoic Age of the birds and the mammals, both of which were better adapted for a way of life on land. There are relatively few present-day reptiles. The fossil record reveals three extinct subclasses and 11 extinct orders in addition to the three subclasses and four orders represented by surviving forms.

The relationship of the subclasses, orders, suborders, and families represented in Illinois may be summarized in the following synopsis.

Subclass Anapsida.—Temporal region of skull encased in bone, fossae lacking.

Order Testudines.—Body enclosed in a shell, consisting of an upper carapace and a lower plastron; jaws toothless.

Suborder Cryptodira.—Toes present;



Fig. 95.—Distribution of *Gastrophryne carolinensis*. Hatching indicates the presumed range of the subspecies *carolinensis* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

4 or 5 claws on each front foot; shell with horny plates.

Family Chelydridae.—Bridge narrow; plastron cruciform, consisting of 9 or 10 plates.

Family Kinosternidae.—Bridge broad; plastron consisting of 11 plates.

Family Testudinidae.—Plastron large, consisting of 12 plates.

Suborder Trionychoidea.—Three claws on each foot.

Family Trionychidae.—Shell depressed, leathery; snout proboscis-like.

Subclass Lepidosauria.—Skull a modified diapsid type.

Order Squamata.—Body completely scaled.

Suborder Sauria.—External ears usually present; movable eyelids usually present; limbs usually present.

Family Iguanidae.—Pineal eye present; subdigital carinae present; venter scaled; femoral pores present.

Family Scincidae.—Pineal eye absent; usually smooth, overlapping scales on dorsum and venter; femoral pores absent.

Family Anguidae.—Longitudinal groove along each side of body (in North American species); femoral pores absent; the only representative in Illinois limbless.

Family Teiidae.—Granular dorsal scales; venter with transverse plates; femoral pores present.

Suborder Serpentes.—External ears absent; movable eyelids absent; limbs always absent.

Family Colubridae.—Hollow, movable fangs and venom glands absent, no loreal pit between eye and nostril on side of head.

Family Crotalidae.—Hollow, movable fangs and venom glands present, loreal pit between eye and nostril.

For ease in identification, the Illinois species of Reptilia are diagnosed in three large keys, the turtles (order Testudines) in one, the lizards (suborder Sauria) in the second,

and the snakes (suborder Serpentes) in the third. Illinois representatives of these three groups may be identified with the aid of the following key.

1. Body enclosed in a shell; jaws without teeth.....Order Testudines, p. 114
- Body not enclosed in a shell; jaws with teeth.....2
2. Body having four legs.....Suborder Sauria, p. 159
- Body having no legs.....3
3. External ear openings present; movable eyelids present; venter scaled or plated, without transverse scutes; mandibles of lower jaw fused anteriorly.....The anguid genus *Ophisaurus* in the suborder Sauria, p. 163
- External ear openings absent; movable eyelids absent; venter with transverse scutes; mandibles of lower jaw separate and free anteriorly.....Suborder Serpentes, p. 172

Order TESTUDINES

Turtles

Seventeen species and subspecies of turtles occur in Illinois. Four species have Illinois populations of one subspecies each and an adjacent intergrade population or an Illinois population that is entirely intergrade between two subspecies. The intergrade populations, although included in the key for identification, have not been regarded as entities.

Most of our turtles are aquatic, although a few species are terrestrial in habit. Some aquatic species are predominantly stream animals; some are pond or lake animals; others occupy either still or running water. One terrestrial species inhabits forest; the other, prairie. They range in size from the 4-inch musk turtle to the 24-inch alligator snapper. Some species are carnivorous, some omnivorous, and some do a certain amount of scavenging. Turtles are of economic importance because several kinds are prized as food for man, the principal food species being the snapping turtle and two species of soft-shelled turtles. Along the major rivers of Illinois, several of the large aquatic testudinids also are utilized for food. Some turtles, particularly the snappers and soft-shells, are accused of being important predators of fish, but the current opinion of fishery biologists is that turtle predation is insignificant insofar as fish populations are concerned.

Most turtles have a courtship preceding mating, and in some species this is an elaborate performance. Turtle eggs are round or elongate, hard-shelled or membranous-shelled, the shape and type of shell depending on the species. Typically, eggs are deposited in early summer in loamy soil several yards from water. The nest excavation and concealing activities are often complicated processes, including the discharging of cloacal water to moisten the nest site. The hatchling turtles emerge from the ground in early fall or, in some instances, the following spring.

The hatchling turtle is recognizable by its small, usually rounded shell, prominent umbilical scar, and sometimes by the retention of the "egg tooth." Growth is relatively slow; the length of time necessary for sexual maturity varies widely with the different species. The longevity of some turtles is apparently similar to that of man. Some species shed their shell laminae at intervals; others do not. In the latter group concentric growth rings are present which may provide an indication of the age of the turtle.

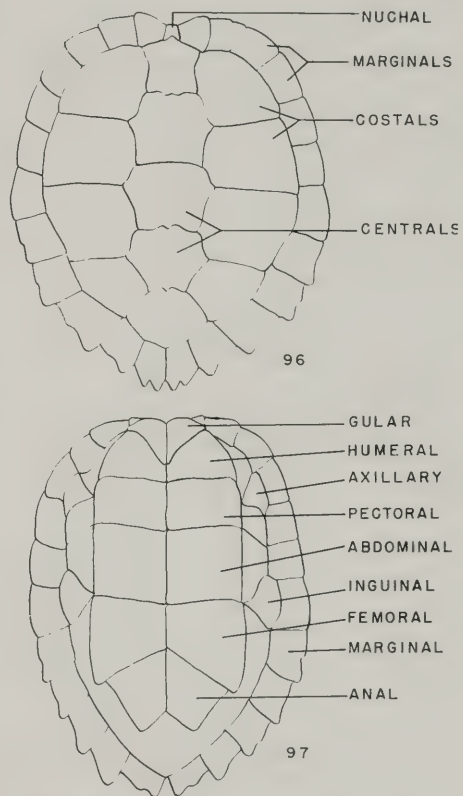
Turtles, particularly young specimens, are popular pets. Because many of them escape or are deliberately released outside their natural range, distributional records must be evaluated with caution.

The 17 species and subspecies of Illinois turtles are divisible into five groups. One group includes six species that are either poorly known (*Kinosternon subrubrum* and *Graptemys pseudogeographica*) or have ranges in which Illinois is approximately centered (*Chelydra serpentina*, *Sternotherus odoratus*, *Graptemys geographica*, and *Trionyx muticus*). Another group (including *Macrolemys temmincki*, *Pseudemys scripta elegans*, and the *Pseudemys concinna* × *floridana* hybrid population) is essentially southern in distribution, with northward extensions into Illinois in the Mississippi River valley. A group of four species (*Clemmys guttata*, *Terrapene carolina carolina*, *Chrysemys picta marginata*, and *Trionyx spinifer spinifer*) is predominantly eastern, and Illinois lies at the western edge of the range of each. The fourth group includes three Great Plains species (*Kinosternon flavescens*, *Chrysemys picta belli*, and *Terrapene ornata*), which reach Illinois from the West. One species (*Emydoidea blandingi*)

is northern, extending southward into Illinois for approximately half the length of the state.

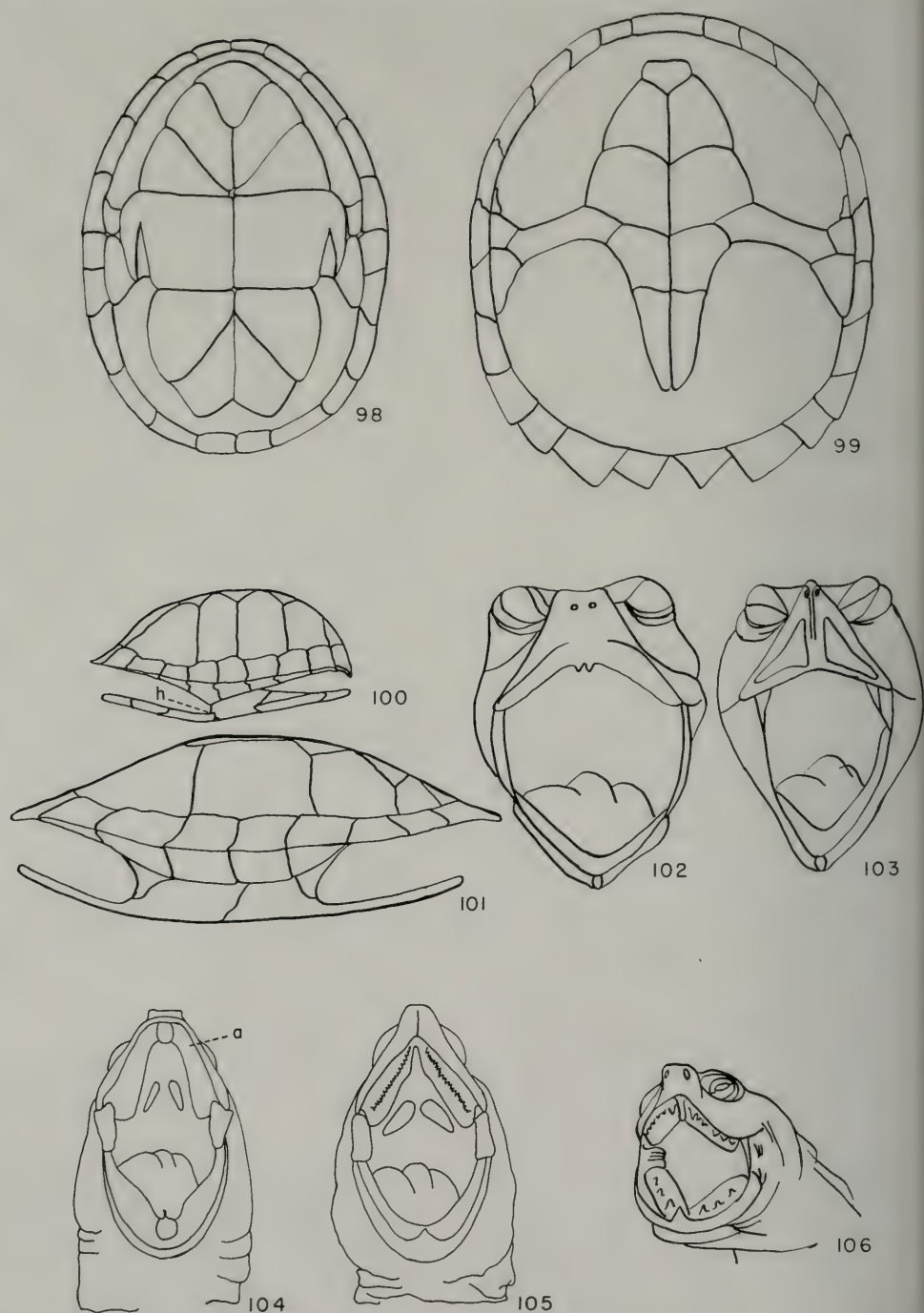
Key to the Order Testudines (Turtles)

- 1. Carapace leathery and covered with skin, without plates; front foot with 3 claws (Trionychidae) 2
- Carapace plated with horny shields, fig. 96; front foot with 4 or more claws... 4



Figs. 96-97.—Dorsal and ventral views of the shell of a turtle, *Graptemys pseudogeographica*.

- 2. Anterior edge of carapace with spiny protuberances; incomplete nasal septa present; 2 lateral head stripes per side... 3
- Anterior edge of carapace smooth; nasal septa absent; 1 light head stripe on each side *Trionyx muticus muticus*
- 3. Black ocelli on carapace sharply decreasing in size peripherally..... *Trionyx spinifer spinifer*
- Central and peripheral ocelli subequal.... *Trionyx spinifer spinifer* × *hartwegi*
- 4. Plastron with 12 plates, fig. 97 (Testudinidae) 9
- Plastron with 11 or fewer plates, fig. 98 5



Figs. 98-106.—Characteristics of turtles: 98, plastron of *Kinosternon flavescens*; 99, plastron of *Chelydra serpentina*; 100, shell of *Terrapene ornata*; 101, shell of *Pseudemys scripta*; 102, head of *Chrysemys picta*, face view; 103, head of *Graptemys pseudogeographica*, face view; 104, jaws of *Graptemys pseudogeographica*; 105, jaws of *Pseudemys scripta*; 106, jaws of *Pseudemys concinna hieroglyphica* $\times$ *floridana hoyi*; a, alveola; h, hinge.

- 5. Plastron with 11 plates; posterior margin of carapace not serrate, fig. 98 (Kinosternidae)6
- Plastron with fewer than 11 plates, fig. 99; posterior margin of carapace serrate (Chelydridae) 8
- 6. Plastron incompletely cornified; head usually with yellow stripes along sides; carapace arched *Sternothaerus odoratus* Plastron completely cornified; head without yellow stripes; carapace depressed.7
- 7. Ninth marginal plate triangular and much higher than eighth; head slate color, without spots *Kinosternon flavescens spooneri* Ninth marginal plate no higher than eighth; top of head with light and dark spots *Kinosternon subrubrum subrubrum* × *hippocrepis*
- 8. Top of head with enlarged plates; carapace with some marginals separated from costals by 3 to 5 supramarginals *Macroclemys temmincki* Top of head without enlarged plates; carapace with supramarginals absent *Chelydra serpentina serpentina*
- 9. Carapace highly domed, the height more than 44 per cent of length, fig. 100; plastron with well-developed hinge, permitting shell to be tightly closed; toes with vestiges of webs only; jaws beaked10
- Carapace not highly domed, greatest height less than 43 per cent of length, fig. 101; plastron with bridge or with limited movement that does not permit shell to be entirely closed; toes webbed; jaws not beaked12
- 10. Carapace with middorsal keel; apex of upper jaw without notch; axillary element absent 11
- Carapace without trace of median keel; apex of upper jaw notched; axillary element present *Terrapene ornata ornata*
- 11. Hind foot with 3 claws; carapace pattern dim or absent. *Terrapene carolina triunguis* × *carolina* Hind foot with 4 claws; carapace boldly marked with yellow or orange *Terrapene carolina carolina*
- 12. Carapace globular; black, with scattered yellow spots13
- Carapace depressed or angular in cross section; shell not black with scattered yellow spots14
- 13. Underside of chin and neck immaculate yellow; many yellow flecks in each carapace shield, each smaller than orbit *Emydoidea blandingi* Underside of chin and neck predominantly dark; a few yellow spots in each carapace shield, some as large as orbit. *Clemmys guttata*
- 14. Marginals marked with red; apical notch in upper jaw flanked by toothlike projections, fig. 10215
- Marginals marked with yellow or with

- greenish white; apical notch in upper jaw, if present, without adjacent "teeth," fig. 103 17
- 15. Plastron immaculate yellow or red; mid-dorsal red stripe half the width of orbit *Chrysemys picta dorsalis* × *marginata* Plastron with a dark figure; middorsal red stripe appearing as a thin line, if visible at all16
- 16. Dark plastral figure occupying 60 per cent or more of plastron, containing light vermiform markings and sending processes peripherally along the seams; carapace with irregular yellow lines at least on costals. *Chrysemys picta belli* Dark plastral figure an elongate central blotch occupying less than 60 per cent of plastron; figure dark, without processes extending along seams; carapace without yellow lines. *Chrysemys picta marginata*
- 17. Alveolar surfaces of upper jaw smooth; apex of lower jaw rounded, fig. 104. .18
- Alveolar surfaces of upper jaw with median ridge or toothlike projections; apex of lower jaw pointed, fig. 105. 19
- 18. A pair of small, isolated yellow spots on occiput, each separated from eye by 2 or more thin, diagonal yellow lines *Graptemys geographica* A pair of boomerang-shaped yellow markings on occiput, each separated from eye by no more than 1 diagonal line *Graptemys pseudogeographica*
- 19. Alveolar surfaces of upper jaw with unequal, toothlike projections, fig. 106; most prominent head markings consisting of a pair of yellow stripes arising on snout and passing between the eyes onto the neck *Pseudemys concinna hieroglyphica* × *floridana hoyi* Alveolar surfaces of upper jaw with median, smooth or finely serrate ridges, fig. 105; most prominent head markings consisting of a pair of red or brown postorbital bands. 20
- 20. Head with pair of conspicuous, red post-orbital stripes; each costal plate with a median, light transverse bar bordered by parallel, thinner dark and light lines *Pseudemys scripta elegans* Head uniformly dark or mottled; post-orbital bands, if present, not red; each costal plate olive or brown, without definite pattern except for dusky margins of carapace seams melanistic *Pseudemys scripta elegans*

CHELYDRIDAE

Two New World genera are placed in the family Chelydridae. A third genus, reported to be restricted to New Guinea, has been shown recently to have been based on an erroneously labeled and misidentified specimen of the common snapping turtle,

Chelydra serpentina. Some authors prefer to include the family Kinosternidae in the Chelydridae.

Chelydra Schweigger

The genus contains only two species, one restricted to Central America and one occurring from southern Canada to Ecuador. The wide-ranging species contains two subspecies, one of which, the nominate subspecies, occurs throughout Illinois.

Chelydra serpentina serpentina (Linnaeus)

Common Snapping Turtle

Testudo serpentina Linnaeus 1758:199 (type locality: "warmer regions"; revised to vicinity of New York City by Schmidt 1953).

Chelonura serpentina, Kennicott 1855:591.

Chelydra serpentina, Davis & Rice 1883a:32.

Chelydra serpentina serpentina, Pope 1939:72-83.

Chelydra sp., Cagle 1944a:105.

Chelydra, Cagle & Chaney 1950:388.

Diagnosis.—A large aquatic turtle (largest Illinois specimen approximately 300 mm. from anterior to posterior end of carapace), fig. 107, with an enormous head, thick, powerful legs, and a relatively long tail; carapace in young with 3 longitudinal keels, in

adults with keels worn off but rough and usually coated with algal growth; posterior edge of carapace serrate; plastron cruciform and inadequate to conceal legs, neck, and tail; head pointed, covered with tuberculate skin; jaws strong; small, paired gular barbels; eyes dorsolateral in position; underside of tail plated with large scales; in young, groundcolor black, with some olive or gray mottling and spotting on sides of head, plastron, and underside of soft parts; subadults and adults dirty olive, gray, or brownish black above, with some evidence of radiating rows of dark flecks on each carapace plate, or carapace almost patternless; soft parts gray or light olive; beak with numerous dark dashes.

Variation.—The basal portion of the tail is on the average longer in the male than in the female of the snapping turtle, and the vent is posterior to the rear edge of the carapace. In the female the anus is usually about even with the posterior edge of the carapace. Although several proportional ratios have been tested in an attempt to find a method for sexing this turtle by external characters, none has proved reliable. Part of the difficulty in sexing these turtles is due to a remarkable change in proportionate tail length as the turtle becomes larger.

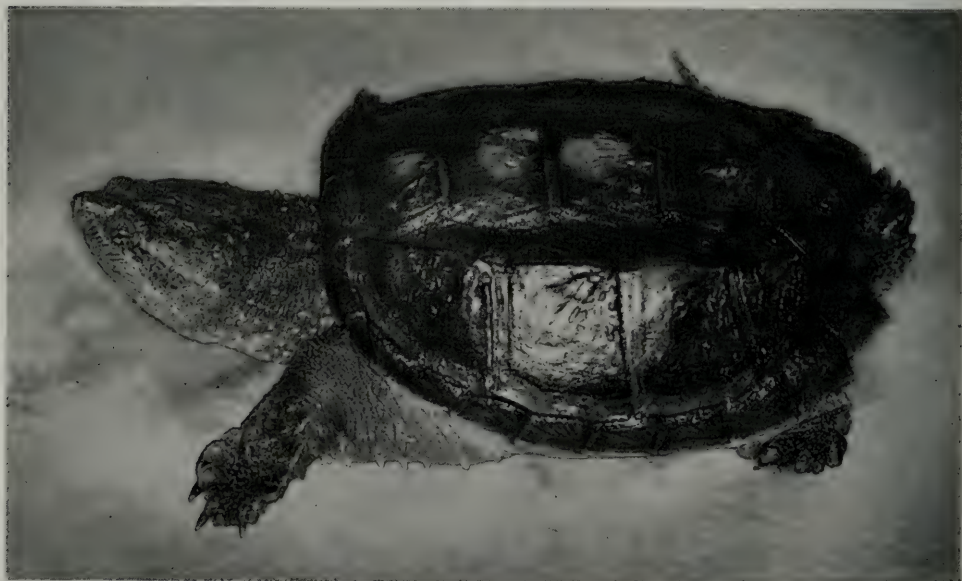


Fig. 107.—An adult *Chelydra serpentina serpentina* from Vermilion County, Illinois. Young specimens are predominantly black; older individuals are dirty olive or brownish black. Most large specimens have growths of algae on the carapace.

The hatchling is almost round and strongly keeled; the tail is considerably longer than the carapace length. The shell is black above and below, with some light spots on the underside. As the animal grows, the keels become less conspicuous, the tail relatively shorter, and the carapace length increases faster than its width. These changes are summarized in table 30. The black color above fades to dark gray or brown, and the

has been found for this turtle. There is individual variation in the number of bridge elements, size of the gular shield, proportions, and color, but these features do not vary clinally. On some turtles the gular is single, in others divided or partially divided.

Habits.—Although the common snapping turtle is aquatic, it may migrate overland from one pond or stream to another. Individuals are often seen on roads, and many

Table 30.—Ontogenetic variation in Illinois *Chelydra serpentina serpentina*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)									
	Under 30(7)		30-50(14)		50-100(6)		100-200(10)		Over 200(3)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Tail length as percentage of carapace length	113-172	130	86-127	107	74-94	82	65-85	72	64-72	67
Carapace width as percentage of carapace length	98-106	100	92-105	97	82-95	89	81-90	86	86-87	86
Third central width as percentage of length of all 5 centrals.....	38.4-44.8	42.4	33.1-48.2	38.5	32.2-39.3	35.4	29.1-34.6	31.8	31.0-31.4	31.2

light spots on the underside increase until eventually the venter is uniformly light olive-gray. The adult loses all trace of the keels, and the highest part of each carapace plate may be worn smooth.

The relationship of the width of the third central plate to the length of all five centrals is of some interest, inasmuch as this ratio is one of the three characters used to separate *Chelydra serpentina serpentina* from the peninsular Florida subspecies, *C. s. osceola*. The northern race is said to have a third central width less than one-third the length of the five centrals. It is evident in table 30 that this ratio is useful only for adults, since specimens under 100 mm. in carapace length would be referable to *osceola* because of the wide third central. The Illinois sample is typical of *C. s. serpentina* in the position of the knobs of the dorsal keels and in the presence of lateral caudal tubercles subordinate in size to the dorsal caudal series.

No geographic variation within Illinois

are killed by cars. They are slow moving and awkward, both on land and in water. When unmolested these turtles probably spend much of their life lying in wait at the bottom of a stream, lake, or pool for prey to come within striking distance of their jaws. They do some stalking. Cahn (1937) describes the gregarious hibernating habits of the species and the harvesting of aggregations by turtle fishermen. I have seen individuals active in late December and early February, although activity in winter may be atypical. 'Turtles of this species do well as captives, and young ones become tame rather quickly. Newly captured individuals are fearless, and their powerful jaws are formidable.

Captive specimens eat almost any kind of food offered. In nature the diet is probably almost equally variable. Feeding habits include some scavenging.

Egg laying by the snapping turtle occurs early in the mornings during June. The nest

is in soil and may be many yards from the nearest water. The spherical eggs are sufficiently resilient to bounce when dropped. Cahn (1937) believed a normal-sized clutch consists of 20 to 30 eggs, each measuring about 33 mm. in diameter. Hatchlings are abroad in September and October. Some are found on highways at this time, presumably making their way from nest site to water.

Illinois Distribution.—The common snapper occurs in almost every pond and stream within the state, fig. 108. Individuals may be found in a great variety of aquatic habitats from small dredge ditches to major rivers and from temporary rain pools to large lakes.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the

distribution map by hollow symbols: CLAY COUNTY: Louisville (Cahn 1937); CLINTON COUNTY: Carlyle (Cahn 1937); COOK COUNTY: Chicago, Riverview Park (Necker 1939c); DE WITT COUNTY: Clinton (Cahn 1937); DU PAGE COUNTY: Downers Grove, Glen Ellyn (Schmidt & Necker 1935); HANCOCK COUNTY: Carthage (Cahn 1937); HENRY COUNTY: Gene-seo (H. Garman 1892); Kewanee (Cahn 1937); JACKSON COUNTY: Elkhart (Cagle 1942b); Grimsby (Cagle 1942a); KANE COUNTY: Elgin (Schmidt & Necker 1935); KANKAKEE COUNTY: Kankakee (Cahn 1937); LAKE COUNTY: Beach, Fox Lake, Highland Park (Schmidt & Necker 1935); Lake Zurich, Waukegan Flats (Necker 1939c); LA SALLE COUNTY: Ottawa (Cahn 1937); LIVINGSTON COUNTY: Pontiac (Cahn 1937); MCHENRY COUNTY: Cary (Necker 1939c); MACOUPIN COUNTY: Carlinville (Cahn 1937); Standard City (Owens 1941); MADISON COUNTY: Cahokia (Baker 1930); MASON COUNTY: Havana (H. Garman 1892); PEORIA COUNTY: Peoria (H. Garman 1892); 11 mi. S Peoria (Burt & Hoyle (1934); POPE COUNTY: Lake Glendale (Cagle 1948); ROCK ISLAND COUNTY: Rock Island (Cahn 1937); ST. CLAIR COUNTY: (Cahn 1937); SALINE COUNTY: Harrisburg (Cagle 1944c); SHELBY COUNTY: Shelbyville (Cahn 1937); WHITE COUNTY: Carmi (Cahn 1937); WILL COUNTY: Hickory Creek (Necker 1939c); WILLIAMSON COUNTY: Marion (Cagle 1942a).

Macrolemys Gray

The single species in this genus is restricted to southeastern United States; it occurs northward in the Mississippi River valley into Illinois. For many years the generic name *Macrochelys* was applied to this turtle.

Macrolemys temminckii (Troost) Alligator Snapping Turtle

Chelonura temminckii Troost 1835:158, footnote (type locality: tributary stream of the Mississippi above Memphis, in western Tennessee).

Macrolemys temminckii, Hay 1892a:560.

Macrochelys temminckii, Cahn 1937:24-34.

Macrochelys temminckii, Parmalee 1954:453-4.

Macrochelys lacertina, Jordan 1873:167.

Macrolemys lacertina, H. Garman 1892:243.

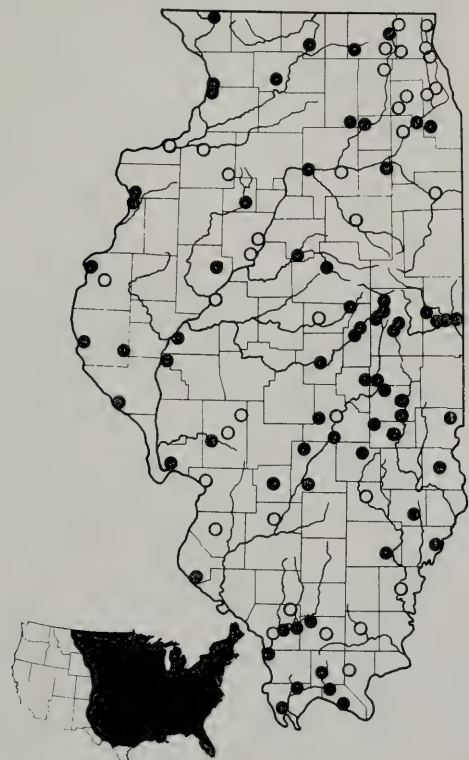


Fig. 108.—Distribution of *Chelydra serpentina*. The subspecies *serpentina* occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

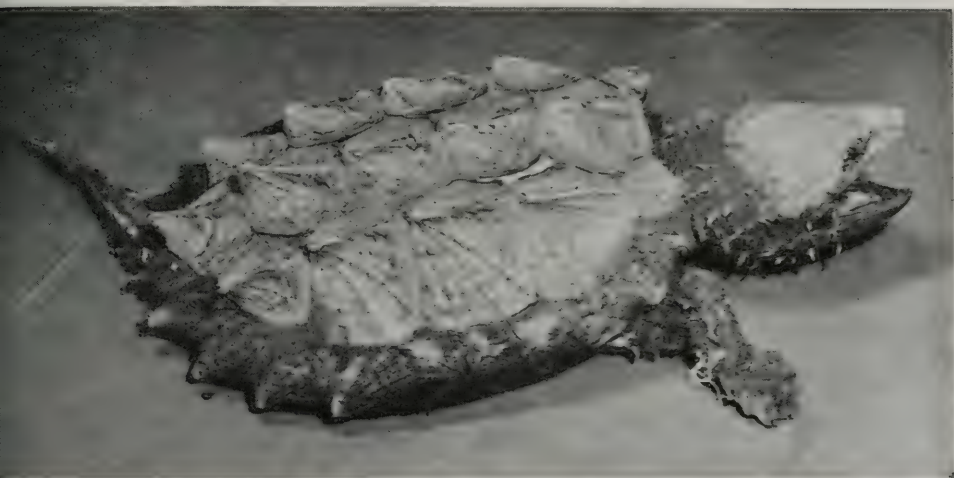


Fig. 109.—A subadult *Macrochelys temminckii* from Jackson County, Illinois. Young specimens are predominantly black; older individuals are dirty olive or brownish black.

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 610 mm.),* fig. 109, similar to *Chelydra* but differing as follows: larger maximum size, carapace of adults as well as juveniles with 3 continuous longitudinal keels; 3 to 5 supramarginal plates separating costals from lateral marginals; eyes lateral in position and not visible from above; top of head covered with large plates; snout, anterior to eyes, long, relatively narrow, and strongly beaked; underside of tail with numerous small scales.

Variation.—The sexes in this turtle presumably differ slightly in the relative position of the anus on the underside of the tail, but the reliability of this character for sexing individuals has not been tested.

The young resemble adults except that they are darker in color and have more rounded and more highly sculptured shells and more conspicuous skin ornamentations.

Almost no data are available for geographic or even individual variation in this turtle within Illinois. Carapace width for four Illinois specimens in the UIMNH collections ranges from 75.5 to 86.5, averaging 8.3, per cent of the carapace length; tail length ranges from 48.6 to 54.6, averaging 2.0, per cent of the carapace length.

Habits.—On land this huge turtle is slow moving and awkward. In water it ap-

parently lies in wait for prey that is attracted to the pink "lure" within the gaping jaws. The dull coloration and algal growth on the carapace make the turtle blend with its surroundings, and the "lure" is the most conspicuous feature of the animal as it rests on the muddy bottom of a stream or swamp. Captive specimens have been found to vary in temperament. A 17-pound specimen displayed the pugnacious behavior implied by the name of the species, but a 60-pound specimen from Tennessee appeared dull witted and reluctant to bite, although it often opened its jaws in threatening display.

Table 31.—Illinois records of *Macrochelys temminckii*.

COUNTY	SOURCE OF DATA	WEIGHT IN POUNDS
Adams.....	H. Garman 1889.....	?
Alexander..	H. Garman 1892....	?
Calhoun.....	Parmalee 1954.....	108
Jackson.....	Cahn 1937.....	96
Jackson.....	UIMNH 24962.....	17
Jackson.....	Jess Grammer.....	160±
Jersey.....	John F. Wanamaker	?
Mason.....	Lewistown Commu- nity High School bi- ology department..	40±
Massac.....	Cahn 1937.....	103
Rock Island	Schroder 1957.....	54
Randolph...	Cahn 1937.....	33
Union.....	H. Garman 1892....	?
Union.....	E. C. Galbreath.....	?
Wabash.....	Hay 1887a.....	?
White.....	H. Garman 1892 ..	?

*Since this account was written, two more specimens have been taken: a record-sized turtle (Jess Grammer, personal communication) and a female ready for oviposition (E. C. Galbreath, personal communication), table 31.

Cahn (1937) reported that the food of the alligator snapper consists primarily of fish, and he presumed that almost any small animal coming within striking distance of the jaws might be eaten.

Almost nothing is known of the life history of this rare turtle within Illinois. The eggs are spherical and presumably much larger than those of any other Illinois species. In the South the number of eggs varies from 15 to 50, presumably the size of the female governing the number deposited.

Illinois Distribution.—The alligator snapper occurs in the Mississippi, lower Illinois, Ohio, and Wabash rivers and their associated tributaries and may occur in swamps and streams throughout the southern fifth of the state. It is extremely rare. In 15 years of collecting and of visiting commercial fishermen, I have never encountered

a specimen in the state, except for a 90-pound individual found dead near Carlyle; subsequently I learned that it had been brought from Tennessee to the local State Fish Hatchery and then discarded. Nevertheless, occasional specimens are taken by Illinois commercial fishermen, and, if they come to the attention of biologists, are reported in the literature, table 31 and fig. 110.

KINOSTERNIDAE

Two genera of this family occur in the United States and Canada. Both are in Illinois. Some authors regard the Kinosternidae as a subfamily of Chelydridae.

Sternothaerus Gray

Four species of *Sternothaerus*, one of which consists of several subspecies, occur in the United States and Canada. The range of one monotypic species covers all Illinois.

Sternothaerus odoratus (Latreille)

Stinkpot

Musk Turtle

Testudo odorata Latreille 1801:122 (type locality: Carolina; revised to vicinity of Charleston, South Carolina, by Schmidt 1953).

Aromochelys odorata, Hay 1887a:16.

Aromochelys odoratus, Davis & Rice 1883a:32.

Sternotherus odoratus, Blanchard 1924b:540.

Kinosternon odoratum, Evermann & Clark 1916:479.

Aromochelys carinatus nec Gray, Davis & Rice 1883a:32.

Aromochelys carinata nec Gray, Hay 1892:593.

Sternotherus sp., Cagle 1944a:105.

Sternotherus, Cagle & Chaney 1950:388.

Diagnosis.—A rather small aquatic turtle (largest Illinois specimen having a carapace length of 128 mm.), fig. 111, with an oval-shaped, usually high-domed shell; 11 poorly ossified plates; pectoral scutes broadly in contact, the suture between at least equal to the interhumeral suture; pectoral scutes never triangular in shape; anterior portion of the plastron much shorter than posterior part; tenth and eleventh marginal plates much higher than anterior marginals; plastron usually with a considerable amount of cartilaginous material bordering the sutures; head large; nose projecting well beyond mouth; a pair of barbels on chin; usually a pair of yellow stripes on each side of head; carapace black, olive, or mottled



Fig. 110.—Distribution of *Macroclemys temminckii*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.



Fig. 111.—An adult *Sternotherus odoratus* from Tazewell County, Illinois. The shell and soft parts are olive, brownish, or black. On most specimens a pair of yellow stripes extends along each side of the head.

brownish black and olive, occasionally with radiating dark lines or series of dashes.

Variation.—The stinkpot male differs from the female in its much larger tail, the prominent claw on the tip of the tail, and the presence of two small horny patches on the inner side of each hind leg. The male tends to have a less ossified and proportionately shorter plastron. In 16 males the plastron length ranges from 67.0 to 78.7 (average 73.3) per cent of the carapace length; in 21 females the range is from 75.0 to 90.3 (average 79.7) per cent.

The hatchlings, which range from 21.5 to 27.2 mm. in carapace length, have black carapaces and soft parts; usually some light marks are present on most of the marginal

scutes. The plastron is marbled with black and yellowish white or gray. The carapace has a prominent middorsal keel and a secondary lateral keel on either side of the middorsal.

Subadults are dark olive or brown and have radiating dark lines or a series of spots on each carapace shield. The venter is predominantly light; the head pattern is similar to that of hatchlings. The middorsal keel is less prominent than in young, and in most individuals the lateral keels have been lost.

In adults the carapace is usually dark above, with some mottling, although it is sometimes almost a uniform olive. It is smooth and exhibits a tendency to become somewhat flattened on top. The head stripes

Table 32.—Ontogenetic variation in carapace proportions of Illinois *Sternotherus odoratus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)							
	Under 30(20)		30–70(2)		70–100(21)		Over 100(15)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	75.2–85.8	82.0	77.0–83.5	80.2	57.5–82.0	72.9	64.5–74.3	68.8
Height as percentage of length.....	52.7–75.5	57.3	46.3–48.6	47.4	37.2–53.2	43.2	37.2–46.2	41.6

may be lost on some very old individuals. The head and neck often have a dimly mottled pattern.

As a stinkpot grows, it becomes progressively more elongate, and the shell becomes somewhat depressed. These ontogenetic changes are summarized in table 32.

No definite geographic variation in this species within Illinois has been noted, although a small series from extreme northern Illinois suggests that the head stripes may be narrower and may be lost at a smaller size in the northern turtles than in turtles from farther south.

Habits.—The stinkpot is aquatic and is not often seen away from water. It is a good swimmer, but its normal behavior consists of crawling over the mud bottom of ponds, searching aquatic vegetation for food. This elongate turtle is notoriously ill-tempered; even a baby turtle not yet free of the egg will snap at objects that annoy it. In addition to its powerful jaws, the stinkpot possesses four scent glands situated on the sides of the body. The musk is extremely unpleasant; many individuals are apparently reluctant to emit the scent.

Sternotherus odoratus is carnivorous, feeding on aquatic arthropods, fish, annelids, and mollusks. Captives take almost any kind of meat offered.

Egg laying occurs in the late afternoons in June. The nest site is several yards from a pond. Cahn (1937) records the clutch size as 3 to 5. The elliptical, hard-shelled eggs, which average about 27.5×15 mm., hatch in early fall.

Illinois Distribution.—The stinkpot undoubtedly occurs in every Illinois county, fig. 112. Although this species is found in rivers and even small streams, it is probably most abundant in permanent ponds and relatively shallow lakes. Usually special efforts must be made to find this turtle in the mud of bodies of water, and for this reason the accompanying map does not reflect the actual abundance of *Sternotherus* in Illinois.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Homewood, Wolf Lake (Schmidt & Necker 1935); DU PAGE COUNTY: Hinsdale (Necker 1939c); FAYETTE COUNTY: Vandalia (Cahn 1937);

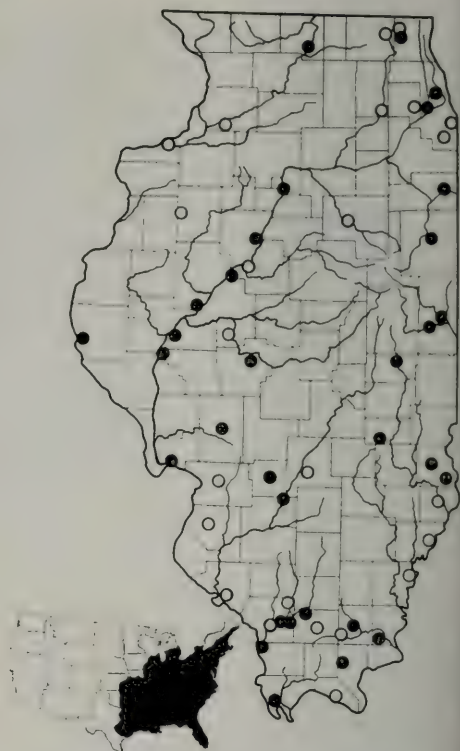


Fig. 112.—Distribution of *Sternotherus odoratus*. The species occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

JACKSON COUNTY: Elkhart, Grimsby (Cagle 1942b); KANE COUNTY: Aurora (Cahn 1937); KANKAKEE COUNTY: Momence (Cahn 1937); KNOX COUNTY: $2\frac{1}{2}$ mi. E Galesburg (Adcock 1922); LAKE COUNTY: Deep Lake (H. Garman 1892); Fox Lake, Nippersink Lake, Round Lake (Schmidt & Necker 1935); LAWRENCE COUNTY: Lawrenceville (Cahn 1937); LIVINGSTON COUNTY: Pontiac (Cahn 1937); McHENRY COUNTY: McHenry (Necker 1939c); MADISON COUNTY: (Hurter 1911); MASSACHUSETTS COUNTY: Metropolis (Cahn 1937); MERCER COUNTY: Petersburg (Cahn 1937); RANDOLPH COUNTY: Chester (Cahn 1937); ROCK ISLAND COUNTY: Rock Island (Cahn 1937); ST. CLAIR COUNTY: (Hurter 1911); SALINE COUNTY: 3 mi. W Carriers Mills (Blanchard 1924b); TAZEWELL COUNTY: Pekin (H. Garman 1892); WABASH COUN-

TY: Mount Carmel (Hay 1887a); WHITE COUNTY: Phillipstown (H. Garman 1892); WHITESIDE COUNTY: Prophetstown (H. Garman 1892); WILLIAMSON COUNTY: Marion (Cagle 1942b).

Kinosternon Spix

Five species of this New World genus, most of them polytypic, occur in the United States and Canada, two in Illinois.

Kinosternon flavescens spooneri Smith Illinois Mud Turtle

Kinosternon flavescens spooneri P. W. Smith 1951:195 (type locality: Henderson County State Forest, 7 mi. N Oquawka, Illinois).

Kinosternon flavescens, Cahn 1931:120-3.

Kinosternon flavescens flavescens nec Agassiz, Pope 1939:52-5.

Diagnosis.—A medium-sized aquatic turtle (largest Illinois specimen with a cara-

pace length of 145.5 mm.), fig. 113, with an obtusely oval, much-depressed shell; plastron large and consisting of 11 plates; pectoral scutes triangular in shape and narrowly in contact; length of interpectoral suture less than one-fourth length of interhumeral suture; ninth marginal more than twice height of eighth marginal; anterior and posterior parts of plastron approximately equal in length; head of medium size; nose not noticeably projecting beyond mouth; paired barbels on chin and neck conspicuous; head a uniform dark above, lighter beneath, with some yellow in patches; carapace black, brownish black, or dark olive, patternless or with black margins along the sutures.

Variation.—Sexual variation in the Illinois mud turtle is similar to that found in the musk turtle. Males possess larger tails, more prominent horny tips on the tail, and two patches of horny skin on the inside of

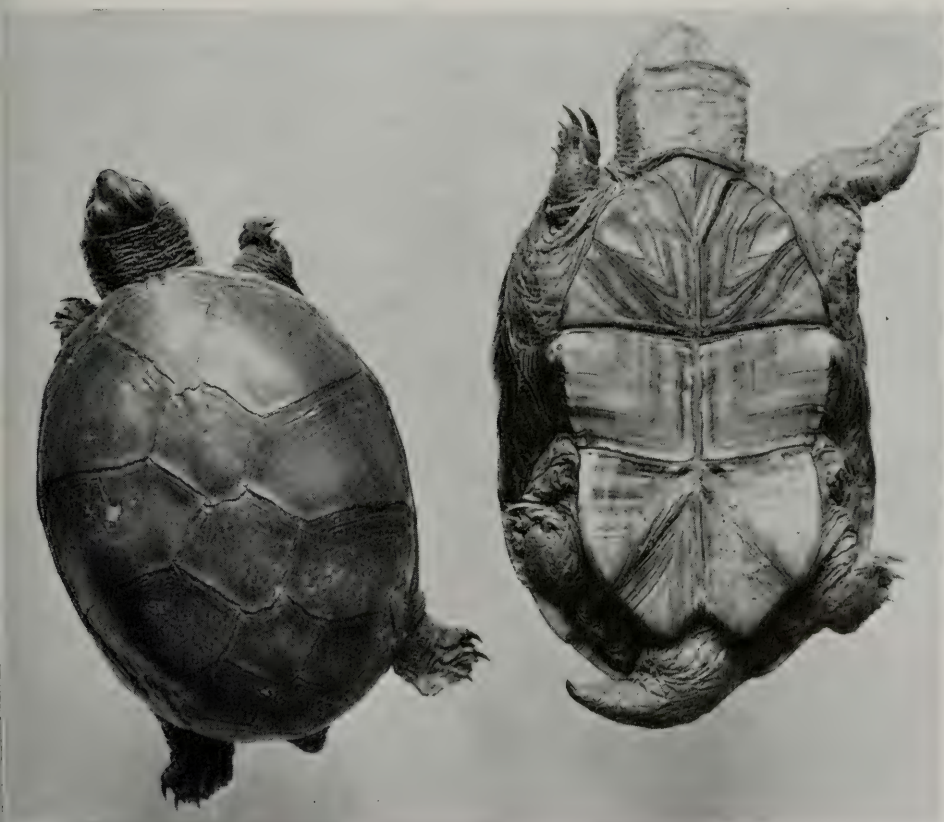


Fig. 113.—Adult *Kinosternon flavescens spooneri* from Mason County, Illinois. Young specimens are nearly black; older individuals, dark olive or brownish black.

each hind leg. Cahn (1937) noted that males tended to be larger and to have heavier upper beaks. The sexual dimorphism in proportionate plastron length is more pronounced in this turtle than in *Sternotherus odoratus*. In nine adult males at hand the plastron length ranges from 84.5 to 87.5

trace of pattern. The beak on old individuals is often flecked with numerous dark dashes.

The carapace of the mud turtle becomes more elongate as this turtle attains adulthood; in old specimens it is even flatter than in juveniles, although the proportionate shell

Table 33.—Ontogenetic variation in carapace proportions of Illinois *Kinosternon flavescens spooneri*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)					
	Under 100(4)		100-130(7)		Over 130(7)	
	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	78.5-87.0	83.4	72.3-82.0	76.9	68.0-71.5	68.9
Height as percentage of length.....	35.3-43.0	39.6	34.0-43.5	39.4	32.1-36.2	33.9

(average 85.4) per cent of the carapace length; in six adult females at hand the range is from 95.0 to 98.5 (average 96.9) per cent.

Data on ontogenetic changes in this species are fragmentary and are at variance with published information. Cahn (1937) described the young as being similar to the adults except that hatchlings are more circular in form and lack the elevated ninth and tenth marginals. Cahn's remarks were based on an examination of Oklahoma juvenile *Kinosternon flavescens flavescens*, however, and it is almost certain that these characters do not apply for *spooneri*, which has a distinctively patterned subadult.

No hatchlings of this species are available from Illinois, but the variation in the adults and subadults extant suggests an ontogenetic change in color and pattern. This change provides an additional character for separating *spooneri* from the subspecies *flavescens*. The smallest specimens at hand are 61 and 70 mm. in carapace length. These subadults are distinctly different from any *K. f. flavescens* and from the largest specimens of *spooneri* in the very dark color of the shell and soft parts and in the irregular but discrete small light markings on the chin. Specimens up to 100 mm. in carapace length retain some trace of the head pattern and in each the underside of the head and neck is dark gray, with yellow restricted to the lower mandible and barbels. Adult specimens are lighter in shell color, and the chin and neck are dark yellow-gray, without a

height does not decrease as regularly as in the musk turtle. The ontogenetic changes in shell proportions are summarized in table 33.

Illinois mud turtles occur in three apparently isolated populations in this state but the samples available are rather homogeneous. Since the original description was published, a few additional specimens have become available to supplement those from which the ratios of plastral elements to each other were derived; the additional data do not appreciably alter the means given in the original description. The gular length ranges from 80 to 140 (average 108) per cent of the interhumeral suture length and from 44.7 to 55.5 (average 50.2) per cent of the length of the anterior lobe of the plastron.

Habits.—The mud turtle is rather slow and awkward on land. In captivity it is adept at digging, even in dry soil. It is a strong swimmer; when undisturbed, it forages in the silty bottoms of ponds and sloughs, plowing a furrow similar to that made by a large mussel. It is timid, preferring to withdraw into its shell rather than try to bite. Newly captured mud turtles emit an extremely nauseating musk; the disagreeable odor of this secretion persists for hours.

The Illinois mud turtle is a scavenger as well as a carnivore. Captives take many kinds of food.

Of two captive females, one laid three eggs and the other four eggs in the latter

half of July. The elliptical, hard-shelled eggs averaged 28.5×16.5 mm. No hatchlings have been collected in Illinois.

Illinois Distribution.—The Illinois mud turtle is known to occur in the sand area along the Illinois River from Morgan to Peoria counties and in Whiteside and Henderson counties, fig. 114. The species may occur also in sand prairie ponds and sloughs of the upper Mississippi River. The preferred habitats are probably backwater sloughs of the major rivers and ponds in the sand prairies.

K. f. spooneri is one of the striking examples of a relict xerothermic period animal. The closest relative occupies the Great Plains from eastern Kansas westward. As a result of the climatic changes occurring in the Prairie Peninsula, the race *spooneri* has

evidently been reduced to a few small remnant colonies.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: PEORIA COUNTY: Peoria (Cahn 1937).

Kinosternon subrubrum (Lacépède)

Three subspecies of *Kinosternon subrubrum* are currently recognized. One is restricted to peninsular Florida, one occurs from the Atlantic Ocean to Alabama and Indiana, and one occurs from Missouri and Mississippi westward into Texas and Oklahoma. The few Illinois specimens available are intermediate between the eastern and western subspecies and are provisionally referred to *K. s. subrubrum* $\times$ *hippocrepis*; the *subrubrum* influence seems to predominate.

Kinosternon subrubrum subrubrum (Lacépède)

$\times$ *hippocrepis* Gray
Mud Turtle

Testudo subrubra Lacépède 1788:618, 619 (type locality: Pennsylvania; revised to vicinity of Philadelphia by Schmidt 1953).

Kinosternon subrubrum subrubrum, Stejneger & Barbour 1917:112.

Kinosternon subrubrum, Pratt 1923:238.

Kinosternon subrubrum ssp., Cagle 1946:691.

Cinosternum pennsylvanicum, Hay 1887a:16.

Kinosternon pennsylvanicum, Hurter 1897:501.

Diagnosis.—An intergrade population of rather small aquatic turtles (largest Illinois specimen with a carapace length of 120 mm.), fig. 115, each of which is similar to *Kinosternon flavescens* but differs as follows: tenth marginal plate distinctly higher than preceding marginals; chin reticulated or mottled; sides of head with discrete light spots; carapace brownish black, olive-brown, or yellow-brown, usually with black margins along the sutures of the carapace.

Variation.—Sexual variation in *K. subrubrum* is apparently similar to that found in *K. flavescens*. The male possesses a larger tail than the female, a more conspicuous nail on the tip of the tail, patches of horny skin on the hind legs, and a proportionately shorter plastron. In an adult male at hand, 94 mm. in carapace length, the plastron length is 90.5 per cent of the carapace length; in an adult female, 120 mm. in carapace

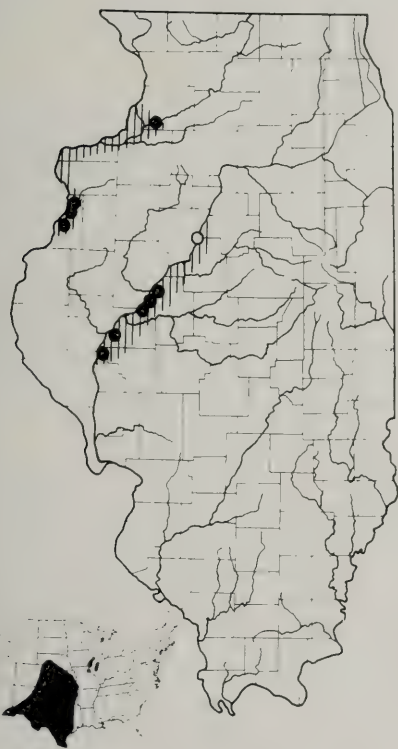


Fig. 114.—Distribution of *Kinosternon flavescens*. Hatching indicates the presumed range of the subspecies *spooneri* in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

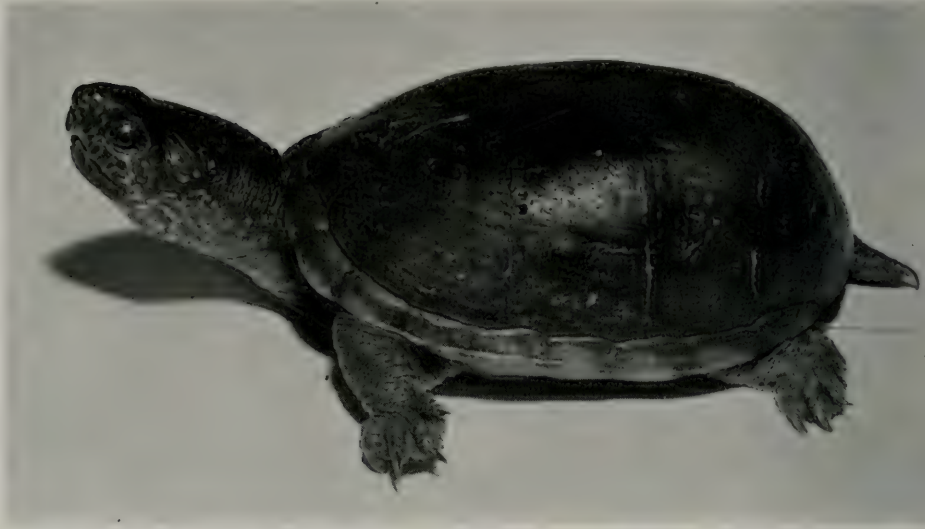


Fig. 115.—An adult *Kinosternon subrubrum subrubrum* from Sussex County, Delaware. The shell and soft parts are olive or brownish black. Specimens from Illinois usually have irregular yellow spots on the head. (Photo by Isabelle Hunt Conant.)

length, the plastron length is 96.7 per cent of the carapace length.

The only Illinois hatchling of this turtle available for study has a carapace 22 mm. long; the width of its carapace is 87.3 per cent of the length (73.5 and 74.5 per cent in two adults), and the height is 49.2 per cent of the length (41.6 and 42.5 per cent in two adults). The carapace of the hatchling, which has a median keel and roughened plates, is thus more rounded and proportionately higher than that of adults. The tenth and eleventh marginal plates are no higher than the anterior marginals. The soft parts, including the head, and the carapace are black; small light marks are present on the edges of the marginals. The plastron is black centrally, light (probably orange in life) peripherally.

The Illinois specimens examined are intermediate in head pattern between the parental subspecies. None has head stripes, but adults have a variable number of discrete light spots on the sides of the head. The sample is too small to provide sufficient data for a study of individual variation.

Habits.—This rare turtle is probably similar in habits to the stinkpot and the Illinois mud turtle, although the impression is given by collectors that *K. subrubrum* is more often found on land than other kinosternids. Captive specimens are rather shy

and usually are not prone to bite. The musk of this turtle is said to be less disagreeable than that of *K. flavescens*. Feeding, nesting, and other habits are probably similar to those of *flavescens*. No life history information is available for this rare species in Illinois.

Illinois Distribution.—The mud turtle is inexplicably rare in Illinois, fig. 116. Southern Illinois habitats that appear to be identical with southern United States habitats, where the species is common, have been searched with little success.

The Illinois range of this turtle is unknown. The Peoria record of H. Garman (1892) and the Mount Carmel record of Hay (1887*b*) would be dismissed as probably referring to misidentified turtles of related species, if it were not that a recently collected specimen from Calhoun County is available, and a colony of *K. subrubrum* is well known in northern Indiana. Most of the recent Illinois records are from the southern tip of the state.

Although undocumented by specimens, published records for the following additional localities are believed valid and are also indicated on the distribution map by hollow symbols: ALEXANDER COUNTY: N Cairo (Cahn 1937); JACKSON COUNTY: NE part of county (Cagle 1942*a*); POPE COUNTY: Dixon Springs (Cagle 1946).



Fig. 116.—Distribution of *Kinosternon subrubrum*. Hatching indicates the presumed range of *subrubrum* $\times$ *hippocrepis* intergrades in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

TESTUDINIDAE

Eight genera in this family are found in the United States and Canada. Six are represented by species occurring in Illinois.

Clemmys Ritgen

Four species of this nearly cosmopolitan genus occur in the United States and Canada. One of these barely enters northeast Illinois.

Clemmys guttata (Schneider) Spotted Turtle

Testudo guttata Schneider 1792:264 (type locality: not stated; suggested as vicinity of Philadelphia, Pennsylvania, by Schmidt 1953).

Clemmys guttata, Necker 1933:8.

Chelopus guttatus, H. Garman 1892:215.

Diagnosis.—A small aquatic turtle (largest Illinois specimen 118.8 mm. in carapace length), fig. 117, with an oval, smooth, rather depressed carapace; posterior marginals flaring outward; plastron large, immovable, consisting of 12 plates; carapace black, each shield with 1 to 10 prominent, round, yellow spots, each of which is almost as large as eye; plastron predominantly black in very old individuals, light groundcolor with prominent black blotches on subadults, and black groundcolor with light central portion in most adults; head rather small and dark, with scattered yellow spots above; neck dark above and below, sometimes spotted with yellow; limbs usually somewhat bicolored, dark above and orange-yellow beneath.

Variation.—Grant (1935) found that the male spotted turtle differs from the female in having a more posteriorly situated anus, a slightly concave plastron (flat or convex in the female), less prominent post-mandibular stripes, brown eyes (orange eyes in the female), and, on the average, fewer yellow crown spots.

Hatchlings, according to Carr (1952), are about 28 mm. in carapace length, almost circular in outline, and have one spot per carapace plate. The young are said to have feeble keels, proportionately longer tails than adults, and plastrons that are light but with a dark central blotch in each.

The three available specimens from Illinois are not sufficient to indicate the extent of variation of the species within the state. Cahn (1937) cites two specimens from near Wolf Lake, Cook County, and he gives measurements for both turtles. My measurements of one of these specimens (the only one now extant) do not correspond to those given by Cahn for either, and this discrepancy precludes use of his data. Two adult females have carapace lengths of 118.8 mm. and 103.6 mm., carapace widths of 81.2 and 75.0 mm., plastron lengths of 109.0 and 96.5 mm., and plastron widths of 61.0 and 59.5 mm. A male has measurements for these characters as follows: 94.2 mm., 71.2 mm., 83.0 mm., and 51.2 mm. The carapace height in the three Illinois specimens available averages about 39 per cent of the length.



Fig. 117.—An adult *Clemmys guttata* from Cook County, Illinois. The groundcolor is black; the spots are yellow.

Habits.—Almost nothing is known of the habits of the spotted turtle in Illinois. In northern Indiana this species is thoroughly aquatic, inhabiting bogs. Carr (1952), summarizing published information on eastern specimens of the spotted turtle, noted that the female lays one to four elliptical eggs in June. The eggs, averaging 30×17.5 mm., hatch in late September. In nature the species is probably carnivorous, but it takes plant material on occasion.

Illinois Distribution.—This eastern turtle was suspected by H. Garman (1892) of occurring in Illinois, but the first specimen was not discovered in the state until 1927. In addition to records examined and plotted, fig. 118, is a published record for Romeoville, Will County (Necker 1939c), inadvertently omitted from the map. The only area in the state where this rare species occurs is rapidly becoming entirely urban.

Emydoidea Gray

One monotypic species of *Emydoidea* occurs in the New World. For many years the North American species was placed in the Holarctic genus *Emys*.

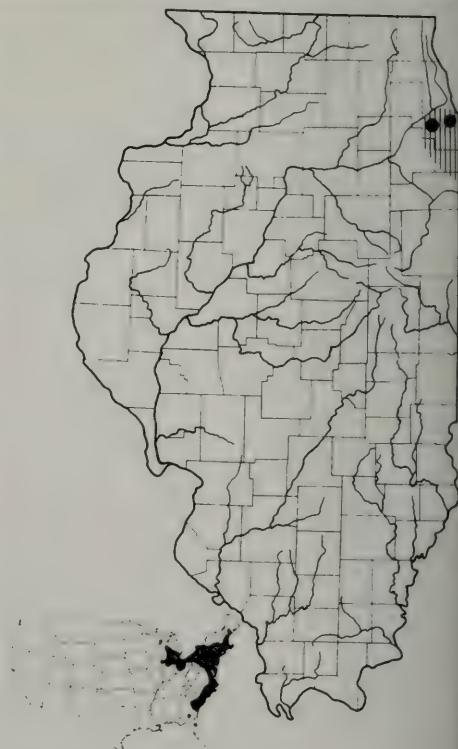


Fig. 118.—Distribution of *Clemmys guttata*. Hatching indicates presumed range in Illinois; circles indicate places represented by specimens examined during this study. The lower map depicts range in the United States.



Fig. 119.—An adult *Emydoidea blandingii* from Whiteside County, Illinois. The ground-color is black or dark brown; the spots and flecks are yellow.

Emydoidea blandingii (Holbrook)

Blanding's Turtle

Cistuda blandingii Holbrook 1838:35, pl. 5
(type locality: Fox River, Illinois).
Cistudo blandingii, Müller 1855:89.
Emydoidea blandingii, Hay 1892a:579.
Emys blandingii, Ditmars 1907:56.
Emys blandingii, Schmidt 1953:93.
Emys meleagris, Yarrow 1882a:37.

Diagnosis.—A medium-sized aquatic and terrestrial turtle (largest Illinois specimen with a carapace length of 240 mm., according to Cahn 1937), fig. 119, with an oblong, somewhat depressed carapace; large plastron consisting of 12 plates, hinged with anterior and posterior lobes movable; head and legs of moderate size; a deep terminal notch in upper jaw; carapace of adult black or dark brown, each plate usually containing numerous small yellow spots and dashes which tend to form radiating series; marginals often reticulate, with equal amounts of brown and pale yellow; plastron of adult yellow, usually with a heavy black blotch on the distal portion of each plastral plate (occasionally old examples are predominantly black below); top of head black or dark brown, often with scattered, small yellow spots; chin and underside of neck chrome yellow. Young specimens usually have some evidence of the radiating series of spots or dashes on each carapace shield, the

adult plastral pattern, and the deeply notched upper jaw. Hatchlings of this species may be patternless, but the deeply notched jaw and longer tail distinguish them from hatchling box turtles.

Variation.—The position of the anus on the tail of Blanding's turtle is posterior to the hind edge of the carapace in the male, anterior in the female. The male has a concave plastron (flat in the female) that is proportionately smaller. In four adult males the plastron length ranges from 89.3 to 93.0 per cent of the carapace length, averaging 90.8 per cent; in seven adult females the range is from 95.5 to 100.0, averaging 97.8 per cent.

In hatchlings, the carapace length ranges from 29.5 to 35.2 mm. The shell is more nearly circular in form and has a heavy but low central keel. The tail length is 65 to 70 per cent of the carapace length. The upper shell is uniformly black or is black except for a poorly defined light spot within each carapace shield. The plastron has a large, black central blotch. The top of the head, neck, and soft parts are black, and the chin has light markings. Lateral light lines are rather prominent on the tail. The lateral edges of the pectoral and abdominal scutes are obtusely angular in juveniles; the edges of these scutes are not inflected in adults.

In older juveniles, radiating yellow-brown dashes are evident around the edges

Table 34.—Ontogenetic variation in carapace proportions of Illinois *Emydoidea blandingi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)							
	Under 40(6)		40-100(3)		100-200(8)		Over 200(3)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	83.0-93.0	87.8	79.5-89.5	84.1	66.5-72.3	69.3	62.0-70.5	66.4
Height as percentage of length.....	39.8-44.0	42.4	40.0-43.2	41.8	32.8-43.0	37.6	33.8-40.7	36.7

of each carapace shield, and the entire chin is light. The chin color encroaches onto the ventral side of the neck in the form of vermiform markings. The keel is less evident than in hatchlings, and the tail is relatively shorter. Ontogenetic changes in shell proportions are given in table 34.

No geographic variation has been discerned for this turtle in Illinois. Individual variation, particularly in the size and distinctness of the light spots on the carapace, is pronounced. In general, older specimens are more distinctly spotted than young; some young adults are shiny black, except for the light spots, which are reduced in number as well as in intensity. Occasional large examples are almost entirely black beneath. The top of the head in some individuals is dark, except for small or large yellow spots, or it may be yellow-brown, reticulated with black.

Habits.—Blanding's turtle is reportedly terrestrial as well as aquatic. In Illinois it appears to be largely aquatic; most of the individuals found on land have been migrating from one body of water to another. This turtle is shy and it shows no inclination to bite when handled. It is a swift swimmer. It takes both plant and animal food.

Copulation in the turtle has been observed on October 15 and on November 17. Cahn (1937) found that the number of eggs laid by a single female ranged from 6 to 10 and that the leathery-shelled eggs averaged 36.5 × 25.0 mm. The time of oviposition is unknown. Females taken in late June had not yet deposited eggs. A number of baby Blanding's turtles were found dead and desiccated on August 26 in sand hills in Whiteside County. These young turtles were presumably hatchlings that had been killed by

the hot sun before they could find their way across several hundred feet of sand to water.

Illinois Distribution.—Blanding's turtle occurs in the northern half of Illinois in areas originally prairie, fig. 120. It now oc-

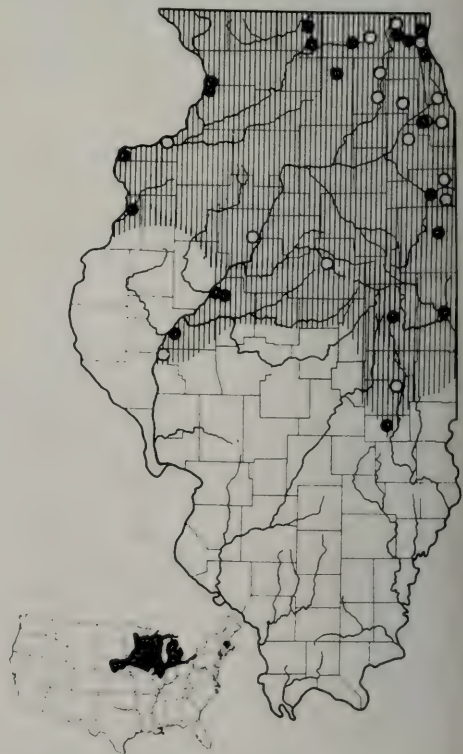


Fig. 120.—Distribution of *Emydoidea blandingi*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

curs only as scattered colonies, although it was probably abundant on the central prairies before the extensive marshes were drained. In a few areas this species is still common, but its distribution is probably discontinuous, except for the floodplain sloughs that margin the large rivers.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COLES COUNTY: 4 mi. N Charleston (Hankinson 1917); COOK COUNTY: Chicago (Yarrow 1882a); Homewood (Necker 1939c); Orland Park (Schmidt & Necker 1935); DU PAGE COUNTY: Lisle (Schmidt & Necker 1935); KANE COUNTY: Batavia, Dundee (Stille & Edgren 1948); KANKAKEE COUNTY: Momence (Schmidt & Necker 1935); Pembroke Township (Necker 1939c); LAKE COUNTY: Lake Forest (Cahn 1937); Pistakee Lake (Schmidt & Necker 1935); Sayer Bog (Necker 1939c); Waukegan (Cahn 1937); McHENRY COUNTY: Woodstock (Schmidt & Necker 1935); McLEAN COUNTY: Normal (H. Garman 1892); MORGAN COUNTY: Meredosia (Cahn 1937); PEORIA COUNTY: Peoria (Cahn 1937); ROCK ISLAND COUNTY: Rock Island (Cahn 1937); WILL COUNTY: Wheatland Township (Necker 1939c).

Terrapene Merrem

Two polytypic species of *Terrapene* occur in the United States. Both species are found in Illinois.

Terrapene carolina carolina (Linnaeus) Eastern Box Turtle

Testudo carolina Linnaeus 1758:198 (type locality: Carolina; revised to vicinity of Charleston, South Carolina, by Schmidt 1953); Schneck 1886:897.

Cistudo carolina, Yarrow 1882a:37.

Cistuda carolina, Hay 1892a:581.

Cistudo carolina carolina, H. Garman 1892:219-20.

Terrapene carolina, Cope 1895b:757.

Terrapene carolina carolina, Stejneger & Barbour 1917:115.

Cistuda clausa, Brendel 1857:254.

Cistudo clausa, Davis & Rice 1883a:32.

Cistudo carolina triunguis nec Agassiz, H. Garman 1892:219-20.

Cistudo carolina triunguis nec Agassiz, Hurter 1893:261.

Terrapene triunguis nec Agassiz, Taylor 1895:584.

Terrapene carolina triunguis nec Agassiz, Schmidt 1953:95.

Diagnosis.—A medium-sized, terrestrial turtle (largest Illinois specimen with a carapace length of 151 mm.), fig. 121, with an obtusely oval, high, globular carapace that

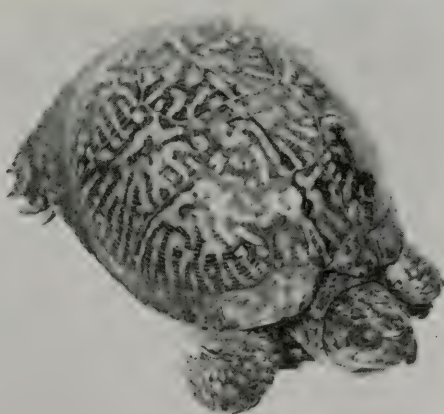


Fig. 121.—Adult *Terrapene carolina carolina* from Johnson County, Illinois. The ground-color is brown or black; the extremely variable markings are yellow or orange.

has a steep rear margin and a slight median keel; plastron completely filling aperture of carapace and bilobed, each lobe attached to a transverse hinge, freely movable and capable of effectively sealing the shell; axillary element absent or rudimentary; bridge absent; beak strongly hooked, not notched at tip; toes with slight web; tail short; carapace brown or black, with extremely variable pattern of yellow or orange markings within each shield; pattern never consisting entirely of straight, narrow yellow lines arranged medially; plastron dark or light, mottled or streaked, but not containing discrete, straight yellow lines; head and legs variable in color and markings.

Variation.—In the eastern box turtle, the male differs from the female in having a more posteriorly situated anus; longer tail; heavier, more curved claws on the hind feet; stouter hind legs; presence of a concavity in the plastron (flat in female); usually red or orange eyes (brown in female); more flaring posterior marginals; and proportionately greater shell height and width. In eight adult males the width of the carapace ranges from 73.6 to 84.8 (average 79.3) per cent of the length and the height from 40.6 to 47.2 (average 44.1) per cent of the length. In 12 adult females corresponding figures are as follows: 76.0 to 87.5 (average 80.5) and 43.0 to 55.0 (average 50.1).

Although hatchlings are remarkably uniform in color and size, the eastern box turtle shows considerable ontogenetic variation. Shell proportions of three size groups are given in table 35. The smallest specimen available has a carapace length of 27.2 mm. Its shell is almost circular and has the appearance of being depressed, despite the presence of a strong central keel. The carapace

of hatchlings is dull brown, except for an indistinct yellow-brown spot in each costal and vertebral shield; the edges of all the marginals are tipped with the same light color. The plastron, which is not obviously hinged at this age, has a black blotch almost filling it, the basic yellowish white color being visible only around its edge. The head and limbs are dull brown; the lower mandible is yellow.

Older juveniles have a more globular carapace, but the central keel is still strongly developed. The plastron is proportionately larger and has an obvious hinge. The juvenile light spots are still evident on the carapace, but there are in addition yellow-brown dashes and spots at the periphery of each vertebral and costal plate. The central black blotch of the plastron usually shows evidence of light markings, and the head and legs are light spotted.

Large juveniles are similar to adults in carapace shape, although the central keel is more prominent. The pattern of the carapace, plastron, and soft parts is exceedingly variable. Old individuals have more widely flaring marginals and only a faint trace of the median keel. In many old turtles a median furrow in the carapace is apparently the result of the costals growing at a faster rate than the vertebral plates.

Individual variation completely defies any attempt to classify pattern types or color. Even in large series it is almost impossible to find a pattern type duplicated. The groundcolor is brown or black, and the markings are yellow-brown, yellow, or orange. In different individuals the plastron may be light or dark, plain, or marked in almost every conceivable manner.

Inasmuch as the Mississippi River has been presumed to be the barrier separating

Table 35.—Ontogenetic variation in carapace proportions of Illinois *Terrapene carolina carolina*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	JUVENILES(9)		SUBADULTS(20)		ADULTS (20)	
	Range	Mean	Range	Mean	Range	Mean
Carapace width as percentage of carapace length.....	87.2-98.0	94.3	78.0-93.0	83.3	73.6-87.5	85.0
Carapace height as percentage of carapace length.....	37.8-51.2	46.1	46.1-53.7	49.2	40.6-55.0	48.7
Plastron length as percentage of carapace length.....	85.5-95.3	90.6	90.5-99.5	95.6	92.2-102.2	95.7

this race from the western three-toed race, *Terrapene carolina triunguis*, in this region, box turtles from the counties bordering the Mississippi have been scrutinized for possible *triunguis* influence. During the course of this survey many specimens have been examined, all of which had 4 toes and distinct markings, until April, 1954, when an adult male was found at Golden Eagle, Calhoun County. This specimen is unquestionably *triunguis*; it has 3 toes, an obscure pattern, and the typical yellow groundcolor. It was found with seven typical individuals of *T. c. carolina* at a presumed breeding site within a few yards of the Mississippi River. This single example may be a waif, or possibly the population between the Mississippi and nearby Illinois rivers consists of intergrades, in which the characters of *triunguis* are recessive to those of *carolina*. In either case, the Illinois turtles must be assigned to *T. c. carolina* in the absence of evidence that a pure *triunguis* population occurs in the state.

Six specimens at hand are presumably *T. o. ornata* $\times$ *T. c. carolina* hybrids. These specimens, all subadults, have been described and figured elsewhere (P. W. Smith 1955). They are worthy of special note inasmuch as they are from prairie outliers which interdigitate in complex manner with a forest habitat in south-central Illinois. All six specimens are referable to *T. ornata* on the basis of shell conformation, absence of keels, presence of both bridges and axillaries, notched upper jaws, and plastral patterns, but the *ornata* pattern is so obviously superimposed on the subadult *carolina* pattern that it is more difficult to conceive this extent of variation in either species than it is to assume hybridization. Three INHS specimens (3494, Marion County; 5956, Richland County; and 3320, Washington County) are intermediate in patterns. Three INHS specimens (3066, Clay County; 3069, Washington County; and 3067, Wayne County) suggest backcrosses, as the *carolina* influence is strongly subordinate to that of *ornata*.

Habits.—In spring and fall the eastern box turtle is conspicuous in the southern half of Illinois. Frequently it is seen crossing roads or is encountered in wooded areas where it appears to be wandering in search of food. In the heat of midsummer, individuals may congregate in mudholes and burrow into the mud. More than 40 turtles

have been taken from one marshy area on a single visit in summer. When in the wild, the box turtle withdraws its head and closes its shell tightly to protect itself from its enemies. As a captive of only a few weeks, it becomes so tame that it cannot be induced to withdraw its head into its shell even if teased. As the time for hibernation ap-



Fig. 122.—Distribution of *Terrapene carolina*. Hatching indicates the presumed range of the subspecies *carolina* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

proaches, the box turtle digs into the soil a short distance each day. By the time of the first freeze, it is sufficiently deep to be protected.

The eastern box turtle feeds on a variety of plant and animal matter. It seems to relish fungi, fruit, berries, and melons and apparently will consume many kinds of invertebrate animals.

There is some evidence that box turtles may congregate for mating. On several

occasions mating pairs have been found close together on a particular floodplain in the spring. Fall mating also may occur. Cahn (1937) records the clutch size as three to eight eggs, each egg measuring about 33×19.5 mm. The leathery-shelled eggs are laid in June and July, often at the edge of woodlands. Hatchlings, although difficult to find, have been taken in September.

Illinois Distribution.—The eastern box turtle is abundant throughout the southern half of Illinois, fig. 122. A few scattered colonies evidently occur in forest islands on the black-soil prairie, but these colonies are only a short distance north of the Shelbyville Moraine. Records from these areas are open to some doubt, inasmuch as picnickers, scouts, and other people often transport turtles to new areas, where they are subsequently released or permitted to escape. An illustration of the difficulty in evaluating these possible waifs is provided by seven specimens taken at Urbana, Illinois. Inasmuch as six of the seven were found within the city, they were probably escaped pets. Nevertheless, the natural range of the species approaches Urbana so closely that some uncertainty remains.

In eastern Illinois, the eastern box turtle occurs north to Vermilion County and is apparently limited in northward dispersal by the tongue of prairie that occupies most of Iroquois and Kankakee counties. In western Illinois apparently suitable habitat extends much farther north than the known range of the turtle. Apparently the box turtle has not yet reoccupied forests in the predominantly prairie areas. In Indiana it is state-wide in occurrence, and it extends well into Michigan.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: EDWARDS COUNTY: Albion (Schneck 1886); FRANKLIN COUNTY: Benton (Cahn 1937); MACOUPIN COUNTY: Standard City (Owens 1941); MADISON COUNTY: Cantine (Hurter 1893); PERRY COUNTY: Du Quoin (H. Garman 1892); RANDOLPH COUNTY: (Hurter 1911); UNION COUNTY: Anna, Cobden (H. Garman 1892); WAYNE COUNTY: Fairfield (Yarrow 1882a); WHITE COUNTY: Carmi, Norris City (Cahn 1937); WILLIAMSON COUNTY: Marion (Cahn 1937).

Terrapene ornata ornata (Agassiz) Ornate Box Turtle

Cistuda ornata Agassiz 1857:445 (type locality: the upper Missouri River and Iowa; revised to junction of the Platte and Missouri rivers by Schmidt 1953); Yarrow 1882a:37.

Cistuda ornata, Hay 1892a:595.

Terrapene ornata, Taylor 1895:582.

Terrapene ornata ornata, Schmidt 1953:95.

Terrapene carolina nec Linnaeus, Hart & Gleason 1907:257.

Diagnosis.—A medium-sized terrestrial turtle (largest Illinois specimen with a carapace length of 128 mm.), fig. 123, differing from the eastern box turtle as follows: size smaller; carapace flatter and never keeled; gular elements longer; axillary element present; upper jaw notched at tip; plastron of subadult and adult always marked with numerous subequal yellow lines on a brown background; carapace brown or black, with narrow, straight yellow lines arranged radially on each shield and a middorsal series of long yellow dashes.

Variation.—Usually the adult male of the ornate box turtle can be readily separated from the adult female by the more posteriorly located anus and the sharply recurved first claw of the hind foot. In some populations males have greenish or bluish heads. Subadults and juveniles, however, lack obvious secondary sexual characters; and even some adults, unlike those of *Terrapene carolina*, are difficult to sex.

Ontogenetic variation is much less pronounced in *T. ornata* than in *T. carolina*. Marr (1944) recorded western juveniles, 30–37 mm. in carapace length, as being rounder, relatively flatter, and having a dorsal ridge, a dark carapace bearing faint yellow spots, and a light-margined dark plastron. The smallest Illinois specimens available are 59.5 and 67.0 mm. in carapace length. These and other subadults have shell proportions almost identical to those of adults. Their color pattern differs from that of adults only in the wider light margin and less distinct yellow lines on the plastron. Measurements of 61 Illinois specimens reveal no progressive ontogenetic changes in shell ratios, although very old adults tend to have more widely flaring marginals.

In Illinois a slight variation in head color of males suggests a geographic correlation, but the correlation is weak and may be fortuitous. Color notes for 14 specimens from



Fig. 123.—A subadult *Terrapene ornata ornata* from Marion County, Illinois. The ground-color is brown or black; the linear markings are yellow.

the sand prairies of central and northern Illinois indicate that approximately 30 per cent of the turtles from these areas have peculiar, uniformly green or blue heads. These strangely colored individuals impart the impression of being stunted or at least unhealthy. About half of the remaining 70 per cent have dark heads without light spots; the other half have dark heads with light spots scattered over the top and sides.

The bizarre head coloring of males is evident on less than 5 per cent of the 44 specimens from the clay soil outlier prairies of western and southern Illinois. Of the 95 per cent with presumably normally colored heads, the majority have distinct light spots.

Individual variation in *T. o. ornata* is less pronounced than in *T. c. carolina*, and probably finds its greatest expression in head color as described above. In 60 specimens shell width ranges from 75.4 to 95.8 (average 85.0) per cent, the carapace height from

45.7 to 56.0 (average 50.0) per cent, and the plastron length from 94 to 105 (average 99) per cent of carapace length. The number and particularly the width of the radiating yellow lines on the carapace are variable, but the raylike arrangement is always present. The plastral pattern is rather constant. One specimen among 60 at hand has 3 toes per hind foot; the others have 4.

Six specimens, which are presumably *T. o. ornata* $\times$ *T. c. carolina* hybrids, have been discussed in the account of variation of *T. c. carolina*.

Habits.—The ornate box turtle is the prairie counterpart of the eastern box turtle. In addition to its fondness for fields, it differs from the eastern box turtle by its more rapid locomotion and quickness to bite when handled. Captive individuals display feeding habits similar to those of *T. c. carolina*, taking both plant and animal foods readily.

Although the species is common in many parts of Illinois, I have never found its eggs except some that had been destroyed by skunks. Nesting habits and development are probably similar to those of the eastern box turtle.

Illinois Distribution.—The range of *T. o. ornata* exhibits one of the most peculiar distributional patterns of all Illinois reptiles, fig. 124. The turtle occurs in isolated relict colonies in all of the central and northern Illinois sand areas, but it is absent from adjacent forested regions and from the black-soil muck prairies. Its range in central and southern Illinois consists of a triangular-shaped tongue with its tip east of Lawrenceville (eastern record is Daviess County in Indiana). This tongue is bounded on the north by the Shelbyville Moraine and on the south by a line connecting Jackson and Wa-

bash counties. Within this area, prairie outliers and forest interdigitate; *T. o. ornata* is probably restricted to the prairie outliers. In many areas the prairie outliers are narrow, and it is possible to collect forest-loving *T. carolina* and prairie-loving *T. ornata* almost side by side.

The enigmatical distribution can be readily explained with the evidence furnished by paleoecology. It can be inferred that the present isolated colonies are remnants of a formerly widespread distribution in the Prairie Peninsula, and that encroaching forest and the increasing mesic nature of this region have reduced the *ornata* habitat to sand prairies in the north and to the savanna-like prairies in the south.

One specimen from Macomb, McDonough County, has not been plotted since its discovery on a sidewalk in the center of the city suggests that it may have been transported there. The literature record (Peters 1942) for Toledo, Cumberland County, may be correct, although numerous visits to this area have revealed only *T. c. carolina*, and the habitat does not appear to be that of *T. o. ornata*.

Although undocumented by specimens, published records for the following additional localities are believed valid and are indicated on the map, fig. 124, by hollow symbols: FRANKLIN COUNTY: Royalton (Cagle 1942a); KANKAKEE COUNTY: Aroma Township (Necker 1939c); Pembroke Township (Schmidt & Necker 1935); MACOUPIN COUNTY: Standard City (Owens 1941); RANDOLPH COUNTY: Baldwin (Hurter 1911); ROCK ISLAND COUNTY: 6 mi. W Cordova (Schroder 1950); WASHINGTON COUNTY: Addieville (Hurter 1893); WAYNE COUNTY: Fairfield (Yarrow 1882a); WILL COUNTY: Bonfield (Necker 1939c).

Chrysemys Gray

One species of *Chrysemys*, with four subspecies, occurs in the eastern United States and Canada.

Chrysemys picta (Schneider)

Three subspecies of *Chrysemys picta* meet and intergrade in Illinois. A western race that apparently is genetically pure occurs in the upper Mississippi River and tributaries



Fig. 124.—Distribution of *Terrapene ornata*. Hatching indicates the presumed range of the subspecies *ornata* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

and intergrades throughout most of the state with a genetically pure eastern race that occurs in southeastern Illinois. A Gulf Coastal subspecies occurs in the Mississippi River as far north as the southern tip of the state, and, although the Gulf Coastal race is not genetically pure in Illinois, its influence is discernible in the intergrade population occupying Alexander County.

***Chrysemys picta marginata* Agassiz**
Midland Painted Turtle

Chrysemys marginata Agassiz 1857:439, pl. 1, fig. 6; pl. 5, figs. 1-4 (type locality: Wisconsin, Iowa, Michigan, and Indiana; revised to northern Indiana by Schmidt 1953); Yarrow 1882a:35.

Chrysemys picta marginata, Bishop & Schmidt 1931:123, 131-7.

Chrysemys marginata marginata $\times$ *bellii*, Necker 1933:8.

Chrysemys picta marginata $\times$ *bellii*, Schmidt 1938b:403.

Chrysemys picta bellii $\times$ *marginata*, Necker 1940:62.

Chrysemys picta dorsalis $\times$ *marginata* $\times$ *bellii*, Cagle 1942a:199.

Chrysemys belli nec Gray, Hurter 1893:260.

Chrysemys bellii bellii nec Gray, Ditmars 1936:417-8.

Emys picta, Kennicott 1855:591.

Chrysemys picta, Yarrow 1882a:34.

Chrysemys picta ssp., Cagle 1942a:199.

Chrysemys sp., Hankinson 1917:328.

Chrysemys marginata treleasei, Weed 1923:48.

Chrysemys cinerea, Baker 1930:55.

Chrysemys picta dorsalis nec Agassiz, Cahn 1937:145-52.

Chrysemys, Cagle & Chaney 1950:388.

Diagnosis.—A medium-sized aquatic turtle (largest Illinois specimen with a carapace length of 166 mm.), fig. 125, with an obtusely oval, depressed carapace; no central keel; posterior margin of carapace smooth, not notched; large, solid plastron, consisting of 12 plates; hind legs somewhat broadened; toes webbed; alveolar surfaces of upper jaw not ridged; terminal notch in upper jaw flanked on either side by a toothlike projection; carapace black to slate-gray, with a thin middorsal red stripe, its sutures sometimes margined with yellow; upper side of marginals with red markings; underside of marginals marbled with red and black; limbs striped with red; head with narrow greenish yellow stripes that become red on the neck; plastron yellow or red, usually with an elongate dark central blotch.

Variation.—In the midland painted turtle the male has conspicuously elongated claws on the front feet. The tail is longer and the anus located more posteriorly in the male than in the female.

The shells of juveniles are more nearly round and proportionately wider than in adults. The thin middorsal stripe is more pronounced and the entire venter is washed with bright red. Larger individuals retain the bright red on the marginals and legs, but the plastron is predominantly yellow. Ontogenetic changes in shell ratios are illustrated by five size classes in table 36.

Geographic variation in *Chrysemys picta marginata* is well marked. In southern Al-



Fig. 125.—A subadult *Chrysemys picta marginata* $\times$ *bellii* intergrade from Tazewell County, Illinois. The groundcolor is black; the markings on the shell margin are red; and the head stripes are yellow.

Table 36.—Ontogenetic variation in carapace ratios of Illinois *Chrysemys picta*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)									
	Under 30(8)		30-60 (12)		60-100 (17)		100-150 (28)		Over 150 (14)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Width as percent- age of length..	93.2-99.5	96.0	85.0-97.0	92.0	76.5-92.3	83.6	72.0-79.2	75.5	70.5-80.0	74.5
Height as per- centage of length.....	42.3-49.7	45.5	36.6-48.3	41.5	34.0-43.0	38.3	29.8-40.2	35.1	30.9-38.2	34.3

exander and Massac counties, occasional specimens display a widened, middorsal red stripe and a reduced, dark plastral blotch. In a few specimens the plastral blotch may be absent. These individuals are identical with the more southern *C. p. dorsalis*. The majority of painted turtles from these counties, however, have a narrow middorsal red stripe and a well-defined plastral blotch. The population therefore may be referred to *C. p. marginata* $\times$ *dorsalis*; since the *marginata* influence predominates in all samples, *C. p. dorsalis* must be excluded from the list of Illinois turtles.

In central and northern Illinois an east-west cline in size and shape of the plastral blotch is evident in the midland painted turtle. In extreme eastern Illinois most specimens have a central blotch without processes, but occasional individuals display dark processes extending peripherally along the plastral sutures. Toward the west the average size of the plastral blotch and the extent of the dark processes rapidly increase. As the plastral blotch increases in size, light markings appear within. The carapace of many central Illinois specimens has yellow lines or dashes, usually one to each costal plate. The carapace of eastern Illinois specimens rarely has yellow markings on the costals.

In western Illinois *C. p. marginata* is replaced by *C. p. belli*. The east-west cline in the nature of the plastral blotch is the result of intergradation of the two races. In eastern Illinois the populations are referable to *C. p. marginata* $\times$ *belli*, although the *marginata* influence predominates. In most of the Sangamon and Illinois river tributaries, the populations are almost exactly intermediate.

Arbitrary numbers, 1 to 6, have been assigned for the relative size and degree of complexity of the plastral blotch as indicated in fig. 126. Numbers 1 and 2 are considered within the normal range of variation of *C. p. marginata*; numbers 5 and 6 are within the range of variation of typical *C. p. belli*. The correlation of blotch size and geography is illustrated in table 37.

Necker (1940) described and illustrated a kyphotic specimen from Fox Lake, Illinois. In pattern this hump-backed anomaly was intermediate between *marginata* and *belli*.

Habits.—Although primarily aquatic, the midland painted turtle is frequently found on land, sometimes well away from permanent water. The species is abundant. In summer, numbers of painted turtles may be seen congregated on floating logs to bask in the sun. Individuals of this species are rather wary in the wild.

The painted turtle is omnivorous and to some degree a scavenger. The stomachs of 25 specimens, collected in July, contained only plants. Cahn (1937) found insects, mollusks, crustaceans, amphibians, fish, and abundant vegetable material in the alimentary tracts of specimens he examined.

This species has an involved courtship in which the male strokes the head of the female with the attenuated claws on the front feet.

Cahn (1937) recorded that the nest sites of the painted turtle are in soil within a few yards of a pond or stream. He reported that 4 to 10, usually 6 or 7, elliptical eggs, averaging about 30×17.5 mm., are deposited at midday. The shells become rather brittle after drying. Hatchlings can be found in September; they may be more in evidence the following spring.

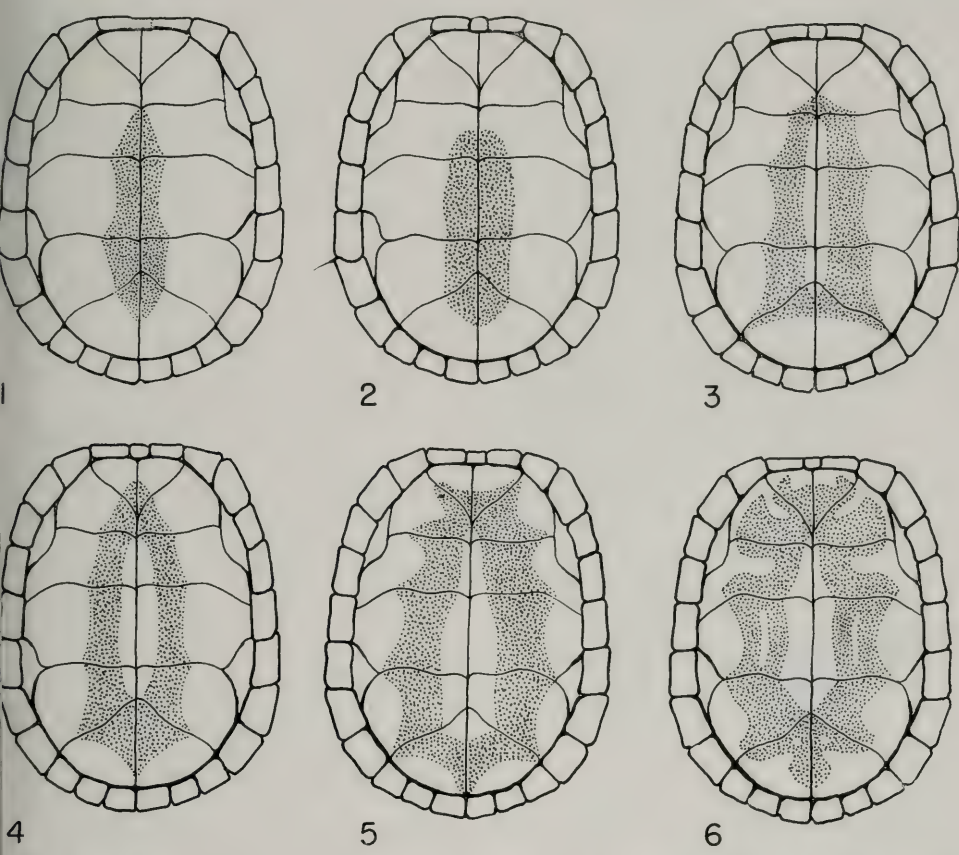


Fig. 126.—Plastral patterns of Illinois *Chrysemys picta*. Numbers 1 and 2 represent typical patterns of *Chrysemys picta marginata*; 5 and 6, patterns within the normal range of variation of *Chrysemys picta belli*; 3 and 4, intermediate patterns frequently exhibited by intergrades.

Table 37.—Geographic variation in plastral pattern of Illinois *Chrysemys picta marginata* $\times$ *belli*. Figures in parentheses are numbers of specimens.

REGION	INDEX NUMBER*	
	Range	Mean
Northeastern Illinois (3).....	1-3	2.0
East-central Illinois (22).....	1-5	2.5
Southeastern Illinois (12).....	1-2	1.5
North-central Illinois (4).....	2-5	3.7
Central Illinois (13).....	1-6	3.2
Southwestern Illinois (12).....	1-6	3.2

*Index numbers are as shown in fig. 126.

Illinois Distribution.—Painted turtles referable to *C. p. marginata* occur only in south-central and southeastern Illinois. *C. picta marginata* $\times$ *belli* intergrades occur throughout the rest of the state except in the

Mississippi River counties north of the confluence of the Illinois and Mississippi rivers, where typical *C. p. belli* replaces the intergrade population, fig. 127. Painted turtles are abundant in almost any aquatic situation, although they are more common in ponds, lakes, and river sloughs than in fast-running streams.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: CLAY COUNTY: Louisville (Cahn 1937); COOK COUNTY: Arlington Heights (Cahn 1937); Carle Woods, Evanston, Jackson Park (Necker 1939c); Lemont, Palos Park, West Pullman (Schmidt & Necker 1935); River Forest (Necker 1939c); Wolf Lake (Schmidt & Necker 1935); CRAWFORD COUNTY: Robinson (Cahn 1937); DE WITT COUNTY: Clinton (Cahn 1937); DU PAGE



Fig. 127.—Distribution of *Chrysemys picta*. Vertical hatching indicates the presumed range of the subspecies *marginata* in Illinois; horizontal lines, that of the subspecies *belli*; cross-hatching in the extreme southern tip of the state, the area of intergradation between *marginata* and *dorsalis*; cross-hatching in the northern three-fourths of the state, the area of intergradation between *marginata* and *belli*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

COUNTY: Lombard, Naperville (Schmidt & Necker 1935); EFFINGHAM COUNTY: Effingham (Cahn 1937); FULTON COUNTY: Lewistown (Cahn 1937); GALLATIN COUNTY: Shawneetown (Cahn 1937); GRUNDY COUNTY: (Necker 1939c); JACKSON COUNTY: Elkhaville, Grimsby (Cagle 1942a); JASPER COUNTY: Newton (Cahn 1937); KANE COUNTY: Batavia, Dundee (Stille & Edgren 1948); KANKAKEE COUNTY: Aroma Township (Schmidt & Necker 1935); Kankakee (Cahn 1937); Pembroke Township (Necker 1939c); LAKE COUNTY: Beach, Burton Ridge, Fox Lake, Grass Lake, Highland

Park (Schmidt & Necker 1935); Dead River (Necker 1939c); Nippersink, Wauconda (Schmidt & Necker 1935); Waukegan (Necker 1939c); LAWRENCE COUNTY: Lawrenceville (Cahn 1937); McHENRY COUNTY: Cary (Schmidt & Necker 1935); McHenry (Necker 1939c); McLEAN COUNTY: Normal (H. Garman 1892); MACOUPIN COUNTY: Carlinville (Cahn 1937); MADISON COUNTY: Cahokia (Baker 1930); MASSAC COUNTY: Metropolis (Cahn 1937); OGLE COUNTY: Oregon (H. Garman 1892); POPE COUNTY: Dixon Springs (Cagle 1946); Glendale (Cagle 1948); PUTNAM COUNTY: Lake Senachwine (Cahn 1937); SALINE COUNTY: Harrisburg (Cahn 1937); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WHITE COUNTY: Carmi (Cahn 1937); Phillipstown (H. Garman 1892); WILL COUNTY: between Wilmington and Kankakee (Necker 1939c); WILLIAMSON COUNTY: Marion (Cagle 1942b); WINNEBAGO COUNTY: 7 mi. S Rockford (Fritsch 1940).

Chrysemys picta belli (Gray) Western Painted Turtle

Emys bellii Gray 1831:31 (type locality: not stated; designated as Puget Sound, Washington, by Schmidt 1953).

Chrysemys bellii, Agassiz 1857:439-40.

Chrysemys bellii bellii, Ditmars 1936:417-8.

Chrysemys picta bellii, Cahn 1937:138-45.

Chrysemys belli, S. Garman 1884:9.

Chrysemys picta belli, Schmidt 1953:100.

Chrysemys picta marginata × *bellii*, Necker 1933:8.

Chrysemys picta belli × *marginata*, Necker 1940:62.

Emys picta, Brendel 1857:254 (part).

Chrysemys treleasei Hurter 1911:235-6, pl. 24 (type locality: Madison, St. Clair, and Monroe counties, Illinois).

Chrysemys picta treleasei, Stejneger & Barbour 1917:118.

Chrysemys cinerea, Baker 1930:55.

Diagnosis.—A medium-sized aquatic turtle (largest Illinois specimen with a carapace length of 177 mm.) differing from *Chrysemys picta marginata* by its larger, more complex plastral pattern and by the usual presence of narrow yellow lines on the carapace. The plastral blotch typically occupies most of the plastron and consists of dark processes extending along most of the plastral sutures. Various light mottling and streaking occur within the blotch. The yellow lines on the carapace typically are ar-

ranged one to each costal shield. This line may be straight or forked and usually traverses the middle of each costal.

Variation.—Sexual and ontogenetic variation in *C. p. belli* are presumably identical with those features in *C. p. marginata*.

Geographic variation in the form of intergradation with adjacent *C. p. marginata* has been described in the discussion of that race, table 37 and fig. 126.

Habits.—The behavior of the western painted turtle is presumably similar to that of *C. p. marginata*. Since *C. p. belli* attains a greater size, as might be expected the eggs are larger. Cahn (1937) cited the average dimensions as 35×18 mm.

Illinois Distribution.—Typical *C. p. belli* is abundant in the Mississippi River and its lesser tributaries from Jersey to Jo Daviess counties, fig. 127. The painted turtles that occur in the Illinois River and in most of the northern three-fourths of the state are intergrades.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CALHOUN COUNTY: Hardin (Cahn 1937); HENDERSON COUNTY: opposite Burlington [Iowa] (Cahn 1937); ROCK ISLAND COUNTY: Rock Island (Cahn 1937).

Pseudemys Gray

Six species, most of which consist of several subspecies, of this New World genus occur in the United States. Two populations inhabit Illinois, one of which is of hybrid origin.

Pseudemys scripta elegans (Wied) Red-Eared Turtle Slider

Emys elegans Wied 1839:213 (type locality: Fox River at New Harmony, Indiana).

Trachemys elegans, Agassiz 1857:435.

Pseudemys elegans, Jordan 1878:165.

Chrysemys scripta elegans, Boulenger 1889:79.

Chrysemys elegans, Hay 1892a:570.

Pseudemys troostii elegans, Stejneger & Barbour 1939:167.

Pseudemys scripta elegans, Cagle 1941:27-8.

Trachemys troostii nec Holbrook, Agassiz 1857:435.

Pseudemys troostii nec Holbrook, Cope 1875:53.
Chrysemys troostii nec Holbrook, Boulenger 1889:76.

Pseudemys scripta troostii nec Holbrook, Pope 1939:224-33.

Pseudemys troostii nec Holbrook, Yarrow 1882a:187.

Chrysemys troostii nec Holbrook, Ditmars 1907:30, 36.

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 229 mm.), fig. 128, with an obtusely oval, depressed carapace; central keel present in juvenile, absent in subadult and adult; posterior margin of carapace notched (except in juvenile); plastron large, solid, consisting of 12 plates; hind legs broadened, adapted for swimming; toes webbed; alveolar surfaces of upper jaw with a smooth or finely serrate median ridge; terminal notch in upper jaw, not flanked by toothlike projections; carapace brown or olive, usually with a conspicuous yellow, transverse bar through the middle of each costal; secondary dark and light stripes paralleling yellow bar; plastron and underside of marginals yellow; a dark spot surrounded by concentric dark rings on most of marginal sutures as seen from below; plastron of juvenile with about 6 pairs of ocelli, each ocellus consisting of 2 or more concentric dark lines; subadult and adult usually with 6 pairs of dark smudges on the plastron; legs and tail with prominent yellow stripes of unequal size; head dark, with several greenish yellow stripes and a conspicuous, broad red temporal stripe on each side of head; red stripes extending from eye onto neck; occasional melanistic male with dusky mottling over entire shell, which obscures typical pattern, and with plastral and carapace sutures usually heavily margined with black.

Variation.—The male of the red-eared turtle differs from the female in having a longer tail, more posteriorly located anus, elongated claws on the front feet, and in the tendency for old males to become melanistic. In old males the color may be brown or olive, with the only pattern consisting of heavy black margins along the sutures of the carapace and plastron. In the adult male the feet are usually black; the head retains some trace of the red postorbital stripe, but fine reticulations replace the other head stripes. In very large females the color may approach that of melanistic males in the development of pigment along the plastral sutures, but the typical pattern of the carapace and soft parts is always evident. The plastron is relatively longer in the female, although this characteristic may be apparent

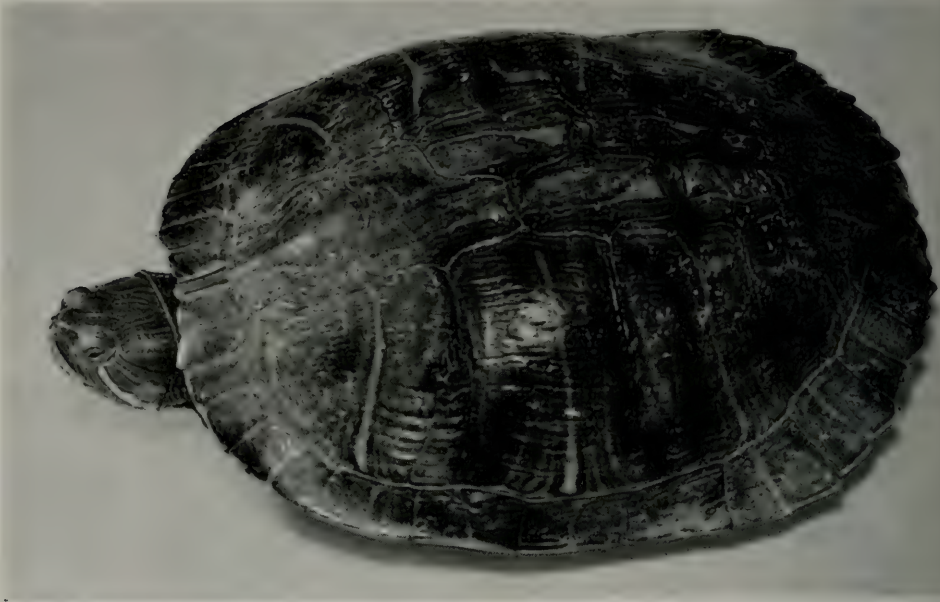


Fig. 128.—An adult *Pseudemys scripta elegans* from Tazewell County, Illinois. The ground-color is green in young specimens, olive or brown in adults; the shell markings are yellowish gray; the head stripes, greenish yellow, except for the wide red stripe behind each eye.

only when measurements are averaged. In 22 males the plastron length ranges from 88.0 to 94.0 (average 91.3) per cent of the carapace length; in 18 females the range is 89.3 to 98.5 (average 94.0) per cent.

The hatchling of this species is green, with greenish yellow markings on the carapace and soft parts. The head has the characteristic red postorbital stripes. The plastron is clear yellow, with paired ocelli, each of which is composed of concentric dark rings. The shell of the juvenile is almost round and has a central keel, which in the hatchling tends to have protuberances. As the

juvenile becomes larger, it loses the green groundcolor of the carapace, and paired dark smudges partially obscure the plastral ocelli. The shell of the subadult is relatively longer and flatter than that of the juvenile, although the central keel may still be found in some specimens as long as 100 mm. The ontogenetic changes in shell proportions are illustrated by the ratios in table 38.

No geographic variation in the red-eared turtle has been discerned within Illinois, but there is considerable individual variation in any one sample. This variation is manifested chiefly in color, in the prominence of

Table 38.—Ontogenetic variation in carapace ratios of Illinois *Pseudemys scripta elegans*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)									
	Under 60 (7)		60-100 (10)		100-150 (16)		150-200 (14)		Over 200 (8)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	85.6-104.0	94.0	83.0-92.0	86.6	76.3-84.3	80.2	74.0-87.8	78.0	73.2-78.1	75.5
Height as percentage of length.....	36.9-53.6	44.7	39.4-42.4	40.8	32.3-39.7	35.9	33.3-41.4	35.6	33.8-38.4	36.2

the secondary light lines on the carapace, in the size of the plastral dark smudges, and in the size of the red postorbital stripes. The extremes in carapace pattern variation range from examples in which the transverse yellow bar is parallel to a larger black bar to other examples in which the secondary light lines are nearly as prominent as the primary light bar, thus obliterating the dark ground-color. The extremes in plastral patterns range from those of occasional individuals in which the ocelli or dark smudges are small to those of individuals in which dark color predominates on the plastron. The postorbital stripes vary in width; in some turtles the stripes may continue onto the neck; in others each stripe may be in the form of a horizontal exclamation mark.

Habits.—Cagle has made detailed studies of this aquatic species in southern Illinois, determining its temperature tolerances, growth rate, and life history. This turtle is active from late April until October. It is a good swimmer, not particularly wary, and enjoys basking on stranded logs, many individuals often congregating for this purpose. It is seldom found on land except when females are seeking nest sites. Cagle (1950) found that males may attain sexual maturity in less than two growing seasons, females in three.

Twenty specimens collected in July contained approximately equal amounts of plant and fish fragments. Cahn (1937) noted that amphibians, crustaceans, mollusks, insects, fish, and plants occurred most often in the stomachs.

The courtship in the red-eared turtle is elaborate and is similar to that exhibited by the painted turtle. Females are often encountered on land in June and July, when they leave the water to lay their eggs. Cagle (1944b) recorded the number of eggs laid by a female as 5 to 22; medium-sized turtles usually deposit about 10. The dimensions of the elliptical, granular-shelled eggs average 36×21.5 mm. Hatchlings have been found in the fall, but they are perhaps more often found in the spring.

Illinois Distribution.—*Pseudemys scripta elegans* apparently occurs throughout Illinois, except possibly in the northernmost counties, fig. 129. Eastern Illinois records are available as far north as Kankakee and southern Cook counties, but the species is probably uncommon in both areas. In west-

ern Illinois the northern limits of the range are unknown; I have not been able to find specimens north of Henderson County. Robert Schroder (personal communication) of Rock Island reported that sliders occur near Moline in Rock Island County. Cahn (1937) plotted records for Rock Island and



Fig. 129.—Distribution of *Pseudemys scripta*. Hatching indicates the presumed range of the subspecies *elegans* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Winnebago counties on his map, although, curiously enough, he failed to cite these records in his list of localities. The species is unknown from Wisconsin and occurs in Iowa only in the southeastern corner. The northern records of Cahn have not been plotted on the accompanying map, inasmuch as the occurrence of the species in extreme northwestern Illinois needs substantiation.

In the southern half of Illinois, red-eared turtles are abundant. Fast-running streams do not usually harbor these turtles, but

many slow streams, lakes, river sloughs, and ponds contain concentrations of them.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CALHOUN COUNTY: Hardin (Cahn 1937); CLAY COUNTY: Clay City, Louisville (Cahn 1937); COOK COUNTY: Orland Park (Necker 1939c); FAYETTE COUNTY: Vandalia (Cahn 1937); FULTON COUNTY: Liverpool (Cahn 1937); GALLATIN COUNTY: New Haven, Shawneetown (Cahn 1937); JACKSON COUNTY: De Soto (Cahn 1937); ELKVILLE (Cagle 1942b); Grimsby (Cagle 1942a); KANKAKEE COUNTY: Altorf Mills (Necker 1939c); Aroma Township (Cahn 1937); LAWRENCE COUNTY: Lawrenceville (Cahn 1937); MACOUPIN COUNTY: Carlinville (Cahn 1937); MADISON COUNTY: (Hurter 1893); MARION COUNTY: Centralia (Cahn 1937); MASSAC COUNTY: Metropolis (Cahn 1937); MENARD COUNTY: Petersburg (Cahn 1937); MONROE COUNTY: Maey's (Cahn 1937); PEORIA COUNTY: Peoria (H. Garman 1892); POPE COUNTY: Dixon Springs (Cagle 1946); ST. CLAIR COUNTY: New Athens (Cahn 1937); SALINE COUNTY: Harrisburg (Cahn 1937); SANGAMON COUNTY: Springfield (Cagle 1946); SCHUYLER COUNTY: Camden (Cahn 1937); TAZEWELL COUNTY: Pekin (H. Garman 1889); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WHITE COUNTY: Carmi (Cahn 1937); WHITESIDE COUNTY: Sterling (Cahn 1937); WILLIAMSON COUNTY: Herrin, Marion (Cagle 1942a).

Pseudemys concinna hieroglyphica
(Holbrook) × ***floridana hoyi*** (Agassiz)
Slider Hieroglyphic Turtle

Emys hieroglyphica Holbrook 1836:47, pl. 2 (type locality: Cumberland River, Tennessee) × *Ptychemys hoyi* Agassiz 1857:433 (type locality: southwestern Missouri; revised to vicinity of Springfield, Missouri, by Schmidt 1953).

Pseudemys hieroglyphica, Davis & Rice 1883a: 32.

Chrysemys hieroglyphica, Hay 1892a:566.

Pseudemys floridana hieroglyphica, Carr 1938: 108.

Pseudemys concinna hieroglyphica, Stejneger & Barbour 1939:164.

Pseudemys concinna, H. Garman 1890:185-6.

Chrysemys concinna, Hay 1892a:568.

Pseudemys labyrinthica, Baur 1893:222, 225.

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 314 mm.), fig. 130, with an obtusely oval, rather flattened carapace, usually with flaring posterior marginals in the adult; central

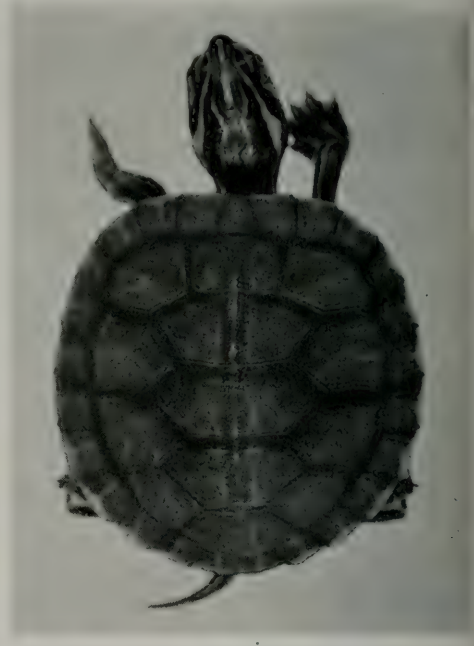


Fig. 130.—A hatchling *Pseudemys floridana hoyi* × *concinna hieroglyphica* from Alexander County, Illinois. The groundcolor is brown; the markings are yellowish gray; the head stripes, yellow.

keel absent except in young; posterior portion of carapace with shallow notches; plastron large, solid, consisting of 12 plates; hind legs broadened, adapted for swimming; toes webbed; alveolar surfaces of both jaws with several subequal spikelike "teeth"; upper jaw without a terminal notch; carapace brown or olive, with a complicated network of light lines, many of which enclose concentric dark rings; each marginal split with an l-shaped light marking; marginal seams dividing concentric light figures; top of head with 6 to 8 narrow, subequal, longitudinal yellow lines and a pair of prominent yellow supratemporal stripes which widen posteriorly; side of head usually with 5 narrow and 3 wider yellow stripes; chin dark, usually with a broad, median, inverted Y-shaped greenish yellow marking, on either side of which are two prominent but subequal yellow lines.

Table 39.—Data for five specimens of *Pseudemys concinna hieroglyphica* × *floridana hoyi* from Illinois. Measurements are in millimeters.

LOCATION OF SPECIMEN	CARAPACE LENGTH	CARAPACE WIDTH	CARAPACE HEIGHT	PLASTRON LENGTH	CARAPACE MARKINGS
INHS.....	314.0	233.0	.....	305.0	Narrow
INHS.....	300.0	208.0	105.0	284.0	Broad
INHS.....	168.0	138.0	57.0	156.0	Broad
UIMNH.....	76.0	62.5	32.0	71.0	Narrow
INHS.....	39.0	39.0	21.2	36.0	Broad

Remarks.—The large slider of the major rivers and associated oxbow lakes of extreme southern Illinois is easily distinguished from *Pseudemys scripta elegans*, but its identity is uncertain. Dr. John W. Crenshaw, Jr., who studied the group very intensively while at the University of Florida, advises me in correspondence that introgression of *P. floridana* genes into the *P. concinna* populations of the lower Mississippi valley has produced an intermediate form. He recommends that the southern Illinois sliders be regarded as hybrids.

P. concinna differs from *P. floridana*, the other parental species, as follows: second costal plate with a light-colored C-shaped marking versus an I- or inverted Y-shaped marking; plastral pattern well developed versus weakly developed; bridge markings contacting adjacent submarginal blotches versus markings separate from blotches; submarginal blotches numerous versus few; and carapace flattened versus more or less globular. *P. floridana* is principally a lake species, *P. concinna* a river species.

Only five Illinois specimens of this large slider have been examined. These are a hatchling, a juvenile, an adult female, and the shells of two adults of undetermined sex. Too few data are available to measure the degree of intermediacy; but, in the five specimens at hand, the characters of *P. c. hieroglyphica* seem to predominate.

Variation.—Carr (1952) noted that the male slider is smaller and flatter than the female; the carapace width averages more than one-third its length in the male, less than one-third in the female. As in *P. s. elegans*, the claws of the front feet of the male are enlarged, and the anus is located posterior to the rear edge of the carapace.

The hatchling mentioned above is almost round and it has a weak central keel, although anterior protuberances are evident.

The shell pattern is similar to that of the adults at hand. The chin pattern is apparently atypical, consisting of a broad, oblong yellow patch, bounded by a pair of narrow dark lines.

Measurements of the five specimens known from Illinois are given in table 39.

Habits.—The slider, or hieroglyphic turtle, is an extremely wary species which probably leaves the water only to bask on logs or cypress knees or to lay eggs. It is a strong swimmer. It is timid and inoffensive.

Cahn (1937) recorded that this turtle eats plant material, crustaceans, amphibians, fish, mollusks, and insects. He also noted that it scavenges a certain amount.

The same author reported that in western Tennessee egg laying occurs in June. The nests are in soil not far from the water. One female was reported to contain nine elliptical, hard-shelled eggs, each measuring approximately 37.5×26 mm.

Illinois Distribution.—The hybrid described here is evidently very rare in Illinois, and it probably is restricted to the large rivers and adjacent lakes in the extreme southern counties, fig. 131. The northernmost records are Mount Carmel, on the Wabash River, and Elsah, on the Mississippi River. Cahn (1937) believed the species was exterminated in Horseshoe Lake, Alexander County, one of the seemingly ideal habitats in Illinois, when this lake went dry in 1930. The most recently collected specimen of this species, however, is a juvenile found in a slough adjacent to Horseshoe Lake, and it appears that this turtle has rehabilitated itself in the lake.

A series of hatchlings present in the University of Illinois Museum of Natural History labeled "Meredosia, Morgan County, Illinois, A. R. Cahn," is almost certainly in error. Several of the Cahn specimens, many of which were probably from Reelfoot Lake,



Fig. 131.—Distribution of *Pseudemys concinna* $\times$ *floridana*. Hatching indicates the presumed range of the species hybrid in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the combined total ranges of the parental species in the United States.

Tennessee, have been assigned to Illinois localities, and this unfortunate situation has made it necessary to be extremely critical of Cahn's records.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: ALEXANDER COUNTY: Cairo (Cahn 1937); HARDIN COUNTY: Elizabethtown (Cahn 1937); JACKSON COUNTY: Murphysboro (Cahn 1937); MASSAC COUNTY: Metropolis (Cahn 1937); UNION COUNTY: (Cahn 1937).

Graptemys Agassiz

Seven North American species, one of which has several subspecies, are included in this New World genus.

Graptemys pseudogeographica (Gray)

Five subspecies are currently referred to this species. The species and subspecies constituting the *Graptemys pseudogeographica* group are too poorly understood, however, for the Illinois turtles to be assigned names with certainty. In most characters all the Illinois members of the group appear to belong to a single population. In head pattern, a character presumably diagnostic in the genus, as many as four of the nominal species seem to be present at one Illinois locality. Collections from other Illinois localities commonly include turtles that key out to two different forms. Accordingly, the small series of specimens available are discussed as *ouachitensis* type, *kohnii* type, *pseudogeographica* type, and *versa* type, but referred to *G. pseudogeographica* subspecies, pending the completion of a monographic study of the genus by F. R. Cagle. Additional collections are needed from the upper Mississippi River.

Graptemys pseudogeographica (Gray) False Map Turtle

Emys pseudogeographica Gray 1831:31 (type locality: Wabash River at New Harmony, Indiana).

Graptemys pseudogeographica pseudogeographica, Weed 1923:48.

Graptemys pseudogeographica, Breckenridge 1944:178.

Malacoclemmys pseudo-geographicus, Davis & Rice 1883a:32.

Malaclemys pseudo-geographica, Hurter 1893:260.

Malacoclemmys lesueuri, Yarrow 1882a:34.

Malaclemys lesueuri, Hurter 1911:243.

Graptemys pseudogeographica kohnii $\times$ *versa*, Carr 1949:10 (map).

Graptemys pseudogeographica kohnii, Carr 1952:202, 207.

Graptemys pseudogeographica ouachitensis, Cagle 1954:185.

?*Graptemys*, Cagle 1944c:5-34.

Diagnosis.—A large aquatic turtle (largest Illinois specimen having a carapace length of 235 mm.), fig. 132, with an obtusely oval carapace that is serrate on posterior edge and has a strong central keel with spikes at least on second and third vertebrals; plastron large, solid, consisting of 12 plates; hind legs broadened, adapted for swimming; toes webbed; alveolar surfaces of upper jaw relatively wide, lacking ridges or "teeth"; head very small in the male, medium-sized in the female. Carapace brown, olive, or

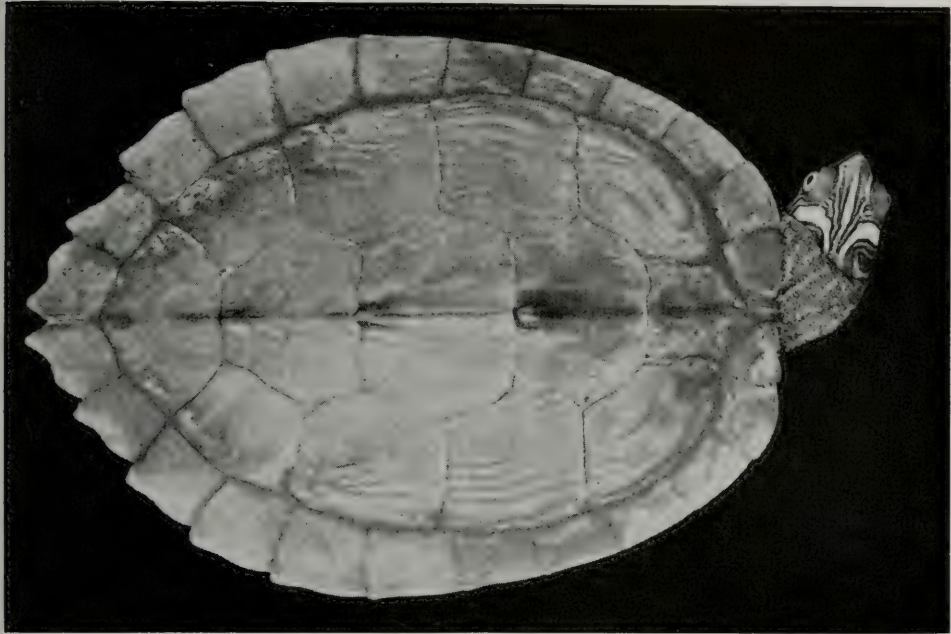


Fig. 132.—A subadult *Graptemys pseudogeographica* from White County, Illinois. The shell is light olive, dull tan, or light brown with dark smudges; the head is conspicuously striped with yellow.

green, with variable pattern of narrow yellow lines and large dark smudges; legs and head dark, with narrow yellow lines; a pair of boomerang-shaped yellow markings or large yellow blotches just behind eyes on top of head; postorbital marking separated from eye, sometimes by a diagonal yellow line, sometimes only by dark groundcolor.

Variation.—If more than one form of false map turtle is involved in our material, sexual dimorphism and ontogenetic variation are very similar in all. The male differs

from the female in its smaller size, decidedly smaller head, more elliptical carapace, long claws on the front feet, longer tail, and more posteriorly situated anus. The plastron is proportionately larger in the female. In nine males the plastron length is 85.1 to 91.2 (average 88.6) per cent of the carapace length, and in 19 females the plastron length is 83.8 to 94.8 (average 91.1) per cent of the carapace length. Other differences in carapace ratios are noted below under ontogenetic variation and in table 40.

Table 40.—Ontogenetic variation in carapace proportions of Illinois *Graptemys pseudogeographica*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)							
	Under 100, Juveniles (8)		100-150				Over 150, Females (11)	
			Males (9)		Females (6)			
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	84.5- 102.0	89.0	70.0-79.2	74.7	76.0-83.4	79.4	74.2-83.2	79.2
Height as percentage of length.....	38.8-47.5	42.1	33.8-40.2	36.7	35.1-40.9	38.7	36.3-42.8	39.2

In juveniles of this turtle the carapace is more nearly circular in shape and relatively higher than in adults because of the prominence of the central keel and spikes. The posterior edge of the carapace is sharply serrate, and some marginals are doubly serrate. The carapace is greenish, with concentric dark figures. The plastron has a large, variable, central dark blotch. The markings on the soft parts are more vivid in young turtles than in adults; configuration of the markings is probably the same at all ages. The ontogenetic decrease in proportionate carapace width and height is rapid in males, more gradual in females, table 40.

Aside from head patterns the only discernible trend in geographic variation for the false map turtle is a slight indication that

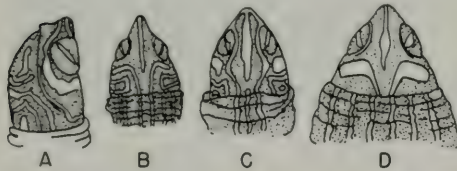


Fig. 133.—Head patterns of *Graptemys pseudogeographica*, all from Morgan County, Illinois (A-D): A, *kohni* type; B, *pseudogeographica* type; C, *versa* type; D, *ouachitensis* type.

heads of males may be proportionately smaller in turtles from western Illinois than in those from other parts of the state. The various head patterns, fig. 133, represented are as follows:

The *ouachitensis* Type.—The most frequent head pattern in Illinois, illustrated in fig. 133D, consists of a pair of prominent, rectangular postorbital markings that are lateral extensions of the narrow, paravertebral light lines. This type also has a large suborbital yellow spot and 3 large yellow spots on the chin, 1 apical and 1 on either side of the lower mandible just anterior to the angle of the jaws. Three to 6 thin yellow lines enter the eye, passing between the postorbital and suborbital yellow markings. This type differs from *Graptemys pseudogeographica ouachitensis* from more southern areas principally in the greater number of yellow lines entering the eye.

The distribution of this type makes little sense geographically. The pattern occurs in specimens from Calhoun, De Kalb, Jackson,

Mason, Morgan, and Shelby counties, Illinois. It also occurs in a specimen from the Mississippi River in Muscatine County, Iowa, and it is the predominant pattern in a series of topotypic *pseudogeographica*, occurring in 7 of the 10 available specimens from Posey County, Indiana.

The *pseudogeographica* Type.—The second most common pattern, fig. 133B, differs from the above in that the postorbital markings are very narrow rather than rectangular and the suborbital and chin spots are reduced or wanting. Five to 7 light lines enter the posterior border of the eye. This type is the *G. p. pseudogeographica* of most recent authors.

It occurs in specimens from Adams, Alexander, Mason, Morgan, Massac, Hardin, Randolph, and Williamson counties, Illinois, and in two topotypic specimens of *pseudogeographica* (Wabash River at New Harmony, Indiana). It occurs in four of the five Mississippi River specimens from Muscatine County, Iowa, suggesting that this pattern may predominate in northern specimens. The occurrence of the same pattern in single specimens from the four southernmost Illinois localities is contradictory.

Two Morgan County, Illinois, specimens and one Posey County, Indiana, specimen could be regarded as intermediate between the *ouachitensis* and *pseudogeographica* patterns.

The *kohni* Type.—A few specimens have a modification of the postorbital bar, fig. 133A. Three specimens, two from Morgan County and one from Cumberland County, Illinois, key out readily as *G. kohni*. In lateral view, the head pattern consists of a prominent, rectangular postorbital marking that continues as an anterior process underneath the eye. The anterior process eliminates the possibility of any light-colored lines entering the orbit. The chin spots are large, as in the *ouachitensis* type. The head of the male is very small. The shell pattern in the *kohni* type is essentially the same as in the other types.

Despite their resemblance in head pattern to *kohni*, the three specimens at hand are referred to *G. pseudogeographica* rather than to *kohni*, inasmuch as *kohni* is presumably a distinctive animal, differing from other forms by its larger head, osteology, and behavior, as well as in head pattern (Cagle, personal communication).

The *versa* Type.—The least common pattern, fig. 133C, can be regarded as a modified *kohni* type. Three specimens, two from Morgan County, Illinois, and one from Posey County, Indiana, differ from the *ouachitensis*, *pseudogeographica*, and *kohni* types in that each has a pair of large square or rectangular postorbital blotches that are isolated and surrounded by incomplete concentric light rings. The chin spots and sub-orbital spots are large. One to 6 light lines enter the posterior border of the eye. The chin shows a tendency toward transverse, although broken, yellow stripes. The head of the male is extremely small for the body size of the animal. These specimens are in essential agreement with descriptions of *versa*.

The current arrangement of the forms of this complex seems to be to recognize *kohni* and *versa* as full species and *pseudogeographica* and *ouachitensis* as subspecies of *pseudogeographica* that intergrade in a wide belt including Illinois and Indiana. If the head patterns are reliably diagnostic, we must assume that three species occur together and may even be taken at the same time in the same net. That three closely related species occur together seems very unlikely. An alternate possibility is that all the pattern types may occur as occasional variants in turtles of a single population. The similarity of all characters except head patterns lends credence to this possibility. A study of substantial series of these turtles from the Illinois and Mississippi rivers might resolve the problem involved; this is one of the most urgent problems in the herpetological taxonomy of eastern United States.

Habits.—The false map turtle, saw-back, or hackle-back, is strictly aquatic and so wary that capture is difficult. It is taken in numbers in fishermen's nets, and occasional individuals are caught by hook and line. The species is gregarious, at least in basking habits; frequently stranded logs may be seen lined with these turtles. Captives are timid and apparently will not bite.

G. pseudogeographica is probably omnivorous. Cahn (1937) found that young specimens fed on vegetable matter, mollusks, and occasional insects. Adults, however, showed evidence of being strict vegetarians, their stomachs yielding only stems of aquatic grasses and sedge bulbs.

Illinois Distribution.—The false map turtle apparently occurs throughout Illi-



Fig. 134.—Distribution of *Graptemys pseudogeographica*. This rather uncommon species apparently occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the combined total ranges of the species *pseudogeographica* and *kohni* in the United States.

nois; and, although it is not abundant, it probably is more common than the available records indicate, fig. 134. It is characteristic of swift rivers but may occur in large lakes. Also, it may be found in bays of large rivers, but it prefers rivers with moderate current and clean bottoms.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: ALEXANDER COUNTY: Cairo (H. Garman 1892); Horseshoe Lake (Cahn 1937); CLINTON COUNTY: Carlyle (Cahn 1937); HARDIN COUNTY: Elizabethtown (Cahn 1937); JACKSON COUNTY: Murphysboro (Cahn 1937); McHENRY COUNTY: McHenry (Cahn 1937); MADISON COUNTY: (Hurter 1911); MONROE COUNTY: Maey's (Cahn

1937); ST. CLAIR COUNTY: (Hurter 1911); UNION COUNTY: Muddy River (Minton & Minton 1948); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WASHINGTON COUNTY: Okawville (Cahn 1937); WHITE COUNTY: Carmi (Cahn 1937).

***Graptemys geographica* (Le Sueur)**
Map Turtle

Testudo geographica Le Sueur 1817:86, pl. 5
(type locality: marsh on border of Lake Erie); Say 1823:32.

Graptemys geographica, Agassiz 1857:436.

Malaclemys geographica, Hurter 1893:261.

Malacoclemmys geographicus, Yarrow 1882a: 33.

Malaclemmys geographicus, McLain 1899:1.

Graptemys geographicus, Shelford 1913:130, 135, 156.

Graptemys, ?Cagle 1944c:5-34.

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 239 mm.), fig. 135, with an obtusely oval carapace; posterior edge of carapace serrate; central keel spiked in juveniles; plastron large, solid, consisting of 12 plates; hind legs broadened, adapted for swimming; toes webbed; alveolar surfaces of upper jaw wide, lacking ridges or "teeth"; no distinct terminal notch in upper jaw; head medium-sized to large; carapace brown, olive, or

green, with a vague pattern of dim light lines and dark smudges on some or all of carapace shields; plastron plain or with variable plastral markings; legs and head dark, with narrow yellow lines; a small, isolated, dorsal yellow spot back of each eye; post-orbital spot separated from eye by 2 or 3 diagonal yellow lines.

Variation.—The male in this species differs from the female in being of smaller size and in having a narrower head, longer tail, more posteriorly located anus, and slightly smaller plastron. There is a tendency for the carapace of the male to be more oval than that of the female. In five males at hand the plastron length ranges from 85.6 to 92.3 (average 87.4) per cent of the carapace length; in 13 females corresponding figures are 84.5 to 92.0 (average 89.3) per cent.

In hatchlings the carapace is strongly keeled with conspicuous spikes, and its width is relatively greater than in adults, table 41. The carapace pattern consists of numerous rounded, concentric figures on a green groundcolor. In older juveniles the keels have less prominent spikes, and the groundcolor is olive or brown, with irregular dark smudges on most of the shields as well as a complex pattern of thin yellow lines. The plastron of juveniles contains a large cen-



Fig. 135.—A subadult *Graptemys geographica* from Vermilion County, Illinois. The shell is light olive, dull tan, or light brown with dark smudges; the head markings are pale yellow or light greenish yellow.

Table 41.—Ontogenetic variation in carapace ratios of Illinois *Graptemys geographica*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	CARAPACE LENGTH (MM.)					
	Under 100 (13)		100–150 (14)		Over 150 (3)	
	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	76.3–91.5	86.4	74.2–86.7	77.1	73.0–79.2	76.7
Height as percentage of length.....	35.2–54.6	40.7	29.7–37.0	33.6	31.7–36.4	34.0

tral dark blotch or 6 to 8 transverse dark markings along the seams.

No geographic variation has been discerned in the limited series of Illinois specimens available. Individual variation is most pronounced in pattern of carapace and plastron and the shape of the postorbital spots. The variability of the pattern features is due to degree of retention of the juvenile pattern in adults. The postorbital spots may be round, triangular, or, in occasional specimens, shaped like an elongate teardrop. Shell pattern varies much as in *pseudogeographica*.

Habits.—The thoroughly aquatic map turtle is difficult to capture because of its wariness and its speed in swimming. It is fond of basking on stranded logs but will dive at the least disturbance and secrete itself among aquatic vegetation. It is found on land only when it is seeking a nest site. This species has been taken in fishermen's nets well into November, showing an apparent reluctance to go into hibernation. Captive turtles are timid, usually refuse food, and show no inclination to bite.

The principal food of the map turtle is mollusks, which are broken by the broad crushing surfaces of this turtle's jaw. Cahn (1937) found insect remains in some individuals.

Cahn (1937) described the egg-laying process as occurring in early morning from late May through June. The nests, in soil some distance from water, contain 10 to 16, usually 12 or 14, elliptical, leathery-shelled eggs, which average about 32 × 21 mm. Hatchlings can be found as early as mid-July, according to Cahn.

Illinois Distribution.—The map turtle occurs throughout Illinois, although it is apparently not abundant, fig. 136. This species shows preference for large rivers, back-water sloughs, and large lakes.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: ALEXANDER COUNTY: Cairo (H. Garman 1892); Horseshoe Lake (Cahn 1937); BUREAU COUNTY: Bureau (Cahn 1937); CASS

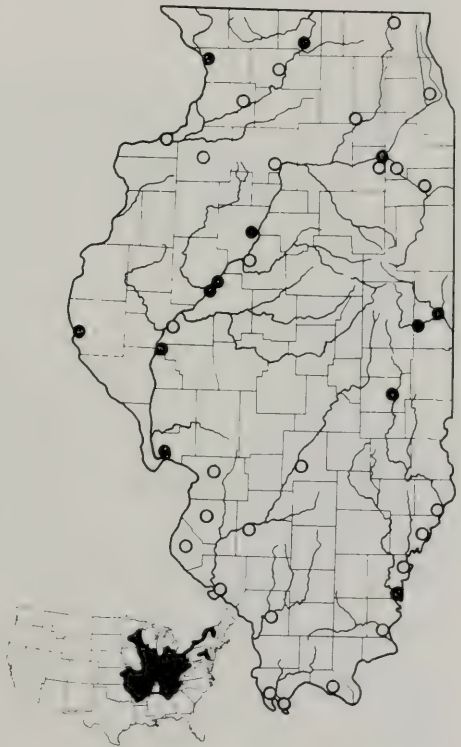


Fig. 136.—Distribution of *Graptemys geographica*. This species occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

COUNTY: Beardstown (Cahn 1937); COOK COUNTY: Chicago (Cahn 1937); FAYETTE COUNTY: Vandalia (Cahn 1937); GALLATIN COUNTY: Shawneetown (Say 1823); GRUNDY COUNTY: Diamond (Stille & Edgren 1948); HENRY COUNTY: (H. Garman 1892); JACKSON COUNTY: Murphysboro (Cahn 1937); KANKAKEE COUNTY: Kankakee (Cahn 1937); KENDALL COUNTY: Plano (McLain 1899); LAKE COUNTY: Fox Lake (Cahn 1937); Nippersink Lake (H. Garman 1892); LAWRENCE COUNTY: St. Francisville (Cahn 1937); MADISON COUNTY: (Hurter 1911); MASSAC COUNTY: Metropolis (Cahn 1937); MONROE COUNTY: (Hurter 1911); OGLE COUNTY: (H. Garman 1892); RANDOLPH COUNTY: Chester (Cahn 1937); ROCK ISLAND COUNTY: Rock Island (Cahn 1937); ST. CLAIR COUNTY: (Hurter 1911); TAZEWELL COUNTY: Pekin (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WASHINGTON

COUNTY: Okawville (Cahn 1937); WHITE COUNTY: Grand Chain [Indiana] (H. Garman 1892); WHITESIDE COUNTY: Sterling (Cahn 1937); WILL COUNTY: Kankakee River (Stille & Edgren 1948).

TRIONYCHIDAE

Only one of the seven genera included in this family occurs in the New World; the remaining genera inhabit only Asia and Africa.

Trionyx Geoffroy St. Hilaire

One monotypic and two polytypic species are recognized in this North American and Asiatic genus. Two species occur in Illinois. These turtles, which for many years were placed in the genus *Amyda*, are among the reptiles that are most highly specialized for life in fresh-water habitats.

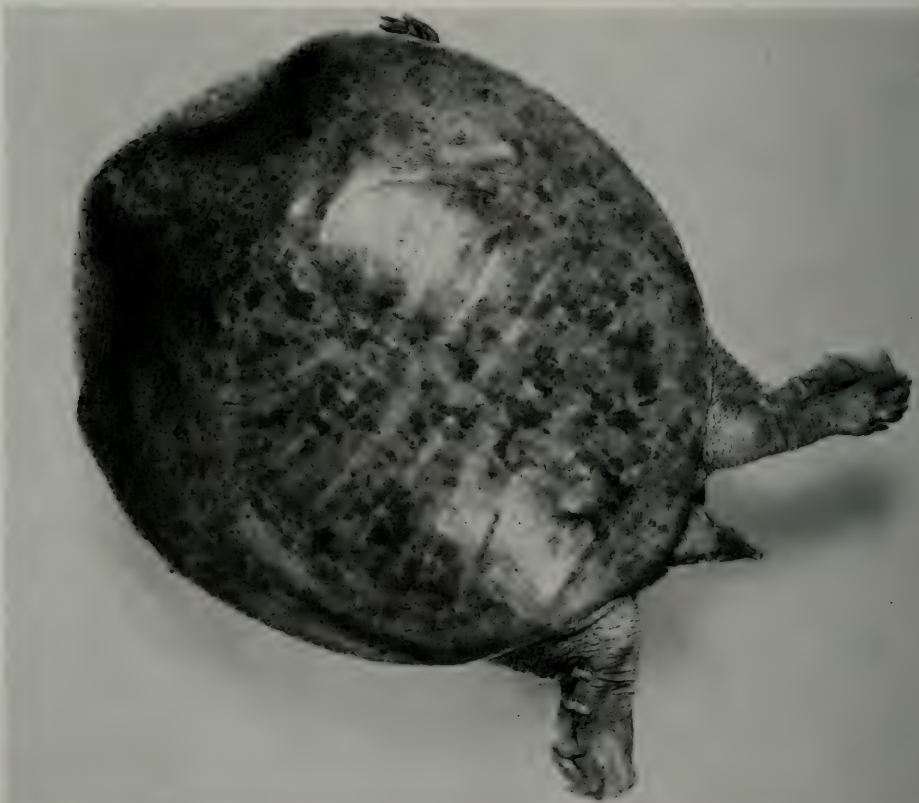


Fig. 137.—An adult *Trionyx muticus muticus* from Wabash County, Illinois. The shell and body are tan above, white below.

***Trionyx muticus muticus* Le Sueur**

Smooth Softshell

Trionyx muticus Le Sueur 1827:263, pl. 7
(type locality: Wabash River at New Harmony, Posey County, Indiana); Hay 1892a: 552.

Amyda mutica, Yarrow 1882a:28.

Trionyx mutica, Cagle 1941:23.

Trionyx, Brendel 1857:255 (part).

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 233 mm.), fig. 137, with an almost round, much-depressed carapace; edges of carapace leathery and flexible; carapace and plastron without plates; nostrils without septa; anterior edge of carapace without tubercles; shell pattern of juvenile and subadult consisting of numerous dots and bacilliform dashes on a tan, olive, or light brown groundcolor; plastron white; sides of head brown, with a single light stripe extending from the eye to the throat on each side of head; chin light; carapace of large adult irregularly mottled or blotched with dark and light.

Variation.—The male of this species differs from the female in being of smaller size and in having a longer tail and a more posteriorly located vent. The anus is posterior to the rear edge of the carapace in the male, anterior in the female.

The young turtle differs from the adult in having a distinct pattern of dark dashes and a more prominent light margin around the posterior and lateral edges of the carapace. The head stripes are better defined on young specimens. In six juveniles the carapace width ranges from 84.2 to 89.2 (average 87.4) per cent and the carapace height from 20.8 to 27.5 (average 24.5) per cent of carapace length. In 11 adults the carapace width ranges from 83.5 to 94.6 (average 88.4) per cent and carapace height from 18.6 to 23.0 (average 20.3) per cent of carapace length.

No geographic variation in this species has been discerned within Illinois. Individual variation is not pronounced. Among juveniles there is a slight range in the number of bacilliform lines and dots. Among adults the distinctness of the carapace pattern and prominence of the light head stripes are variable. The plastron is usually immaculate white; in occasional turtles a small amount of dusky mottling is present on the anterior portion of the plastron and on the

underside of carapace margins. One specimen (INHS 2148 from Morgan County) is kyphotic, the hump projecting so high that the carapace height is almost one-third its length.

Habits.—The smooth soft shell is similar to *Trionyx spinifer* in many respects, but it differs markedly in habitat and temperament. It often lies buried at the edge of water but only in clean sand; it avoids mud- and rock-bottomed streams. Captives withdraw their heads completely into the shell, and I have never encountered an individual that showed a willingness to bite. This species presumably has hibernating habits similar to those of *T. spinifer*, although no information on this subject is available. In summer, large numbers of *muticus* may be seen basking on sandbars in certain areas.

T. m. muticus is primarily a carnivorous animal. Cahn (1937) found that stomachs usually contained crustaceans, fish, amphibians, insects, and mollusks. Plant feeding and scavenging are probably uncommon if they occur at all.

The eggs of this turtle are laid in sandbanks quite near the edges of rivers. Cahn (1937) noted that young females lay five or six eggs, large females as many as 31. The spherical eggs average about 22.6 mm. in diameter. Nesting occurs in June and early July; eggs almost ready to hatch have been found in early September.

Illinois Distribution.—The smooth soft-shell is evidently restricted to rivers with relatively clean, sandy bottoms and with frequent sand bars. The species is known throughout the southern half of Illinois and along the sandy stretches of the Illinois and Mississippi rivers, fig. 138. Although records are lacking for the Chicago area, the species may be present there; it has possibly been overlooked in the sand-bottomed rivers of Kankakee and Iroquois counties. These streams appear to afford ideal habitat. The sluggishly moving and mud-bottomed streams of much of the Grand Prairie of northern and central Illinois do not seem to provide suitable habitat.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: ADAMS COUNTY: Quincy (H. Garman 1892); ALEXANDER COUNTY: Cairo (H. Garman 1892); Horseshoe Lake (Cahn 1937); CAR-

Trionyx spinifer Le Sueur

Five subspecies of *Trionyx spinifer* have been described. The nominate race occurs throughout Illinois. A slight genetic influence of another western subspecies is discernible in the population inhabiting the upper part of the Mississippi River.

Trionyx spinifer spinifer Le Sueur
Eastern Spiny Softshell

Trionyx spinifer Le Sueur 1827:258, pl. 6 (type locality: Wabash River at New Harmony, Posey County, Indiana); Hurter 1893: 260.

Aspionectes spinifer, Agassiz 1857:404-5.

Trionyx spinifer, Dittmars 1907:77.

Amyda spinifera, Hurter 1911:252.

Platypeltis spinifera, Hankinson 1917:328.

Trionyx spinifera, Schmidt 1938b:21-3.

Amyda spinifera spinifera, Necker 1939d:3.

Trionyx spinifera spinifera, Cagle 1941:23.

Amyda spinifera hartwegi $\times$ *spinifera*, Conant & Goin 1948:10-1.

Amyda ferox spinifera, Carr 1952:428.

Trionyx ferox nec Say, Kennicott 1855:591.

Aspionectes ferox nec Say, H. Garman 1892: 215.

Amyda ferox nec Say, Schmidt & Necker 1935: 60.

Amyda ferox hartwegi, Carr 1952:433-5(1).

Trionyx, Brendel 1857:255 (part).

Amyda, Baker 1936:243, 245.

Diagnosis.—A large aquatic turtle (largest Illinois specimen with a carapace length of 282 mm.), fig. 139, similar to *Trionyx muticus*, but differing as follows: nostrils with incomplete septa; anterior edge of carapace lined with tubercles; each side of head dark, a postorbital light stripe and a light line passing posteriorly from the angle of the jaws; neck and legs olive, mottled with dark; carapace in juveniles and in some adults tan, olive, or dull brown, with scattered, round dark circles or ocelli rather than bacilliform dashes; carapace in large adults sometimes with ocelli but usually irregularly mottled.

Variation.—In *T. spinifer spinifer*, the male is smaller and has a longer tail than the female; its anus is posterior to the rear edge of the carapace. The male usually has a carapace with sandpaper-like texture, whereas the female tends to have fewer and larger shell tubercles, particularly in the middorsal region. The adult female loses the pattern of dark ocelli and usually is mottled.



Fig. 138.—Distribution of *Trionyx muticus*. Hatching indicates the presumed range of the subspecies *muticus* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed valid. The lower map depicts the total range of the species in the United States.

ROLL COUNTY: 5 mi. S Savanna (Stejneger 1944); CLAY COUNTY: Louisville (Cahn 1937); CLINTON COUNTY: Carlyle (Cahn 1937); CRAWFORD COUNTY: Robinson (Cahn 1937); FAYETTE COUNTY: Vandalia (Cahn 1937); GALLATIN COUNTY: Shawneetown (Cahn 1937); HANCOCK COUNTY: between Warsaw and Hamilton (Stejneger 1944); JACKSON COUNTY: Murphysboro (Cahn 1937); MARION COUNTY: Centralia (Cahn 1937); POPE COUNTY: Golconda (Cahn 1937); RANDOLPH COUNTY: Chester (Cahn 1937); RICHLAND COUNTY: Olney (Stejneger 1944); ROCK ISLAND COUNTY: Rock Island (Cahn 1937); ST. CLAIR COUNTY: Mississippi River at St. Louis (Hurter 1893); WHITE COUNTY: Carmi (Cahn 1937); WHITESIDE COUNTY: Sterling (Cahn 1937); WOODFORD COUNTY: (H. Garman 1892).

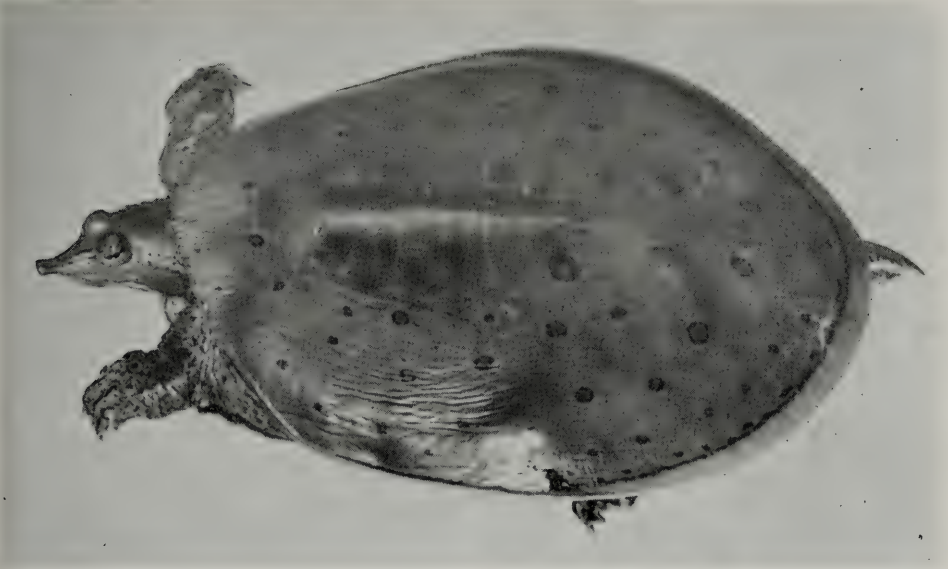


Fig. 139.—A subadult *Trionyx spinifer spinifer* from Tazewell County, Illinois. The shell and body are tan or brown above, white below.

The juvenile is paler than the adult, and the carapace markings and the mottling of soft parts are more prominent. Both proportionate width and height of the shell decrease as the turtle becomes adult. Since the male is intermediate in size between the juvenile and the adult female, changes in shell ratios can be illustrated by comparing the means of carapace width to length and carapace height to length ratios of juveniles, males, and females, table 42.

Geographic variation in the eastern spiny softshell within Illinois is manifested by an east-to-west reduction in the size of the central ocelli of the carapace. This clinal variation represents intergradation of eastern *spinifer* with *hartwegi*, which occurs west of the Mississippi River. In eastern Illinois

the ocelli of *spinifer* are typically large in the center of the carapace; they decrease in size toward the periphery of the shell. In western Illinois occasional specimens have enlarged central ocelli, but the majority tend to have less difference in size between central and peripheral ocelli. These characters are difficult to measure and, since no north-to-south variation has been discerned, the patterns of the available material have been assigned to "*hartwegi*-like," "intermediate," or "*spinifer*-like" groups and divided into a western Illinois sample and an eastern Illinois sample, table 43.

The data shown in table 43 are essentially in agreement with the findings of Conant & Goin (1948), who described *hartwegi*, except that our samples suggest that

Table 42.—Ontogenetic variation in carapace ratios of Illinois *Trionyx spinifer*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	JUVENILES (10)		ADULTS			
			Males (15)		Females (15)	
	Range	Mean	Range	Mean	Range	Mean
Width as percentage of length.....	85.7-93.7	89.5	83.2-92.4	86.5	82.4-88.7	85.0
Height as percentage of length.....	22.2-28.6	26.8	19.4-27.7	23.4	20.4-27.8	25.2

the area of intergradation is somewhat larger in Illinois (and also probably in Missouri) than that indicated by these authors.

Individual variation in the eastern spiny softshell is manifested in groundcolor, size and number of ocelli on the shell, amount of dark spotting or mottling on the underside of the carapace, and distinctness of dark mottling of the soft parts. On some individuals the postocular and lower lateral light head stripes unite on the sides of the neck. One specimen in the sample of 50 at hand lacks the characteristic tubercles on the leading edge of the carapace.

Table 43.—Geographic variation in patterns of Illinois *Trionyx spinifer*. Figures in parentheses are numbers of specimens.

PATTERN	PER CENT OF EASTERN ILLINOIS SPECIMENS (21)	PER CENT OF WESTERN ILLINOIS SPECIMENS (36)
<i>T. s. spinifer</i> -like....	67	22
Intermediate.....	19	50
<i>T. s. hartwegi</i> -like..	14	28

A dried shell of a kyphotic specimen in the University of Illinois Museum of Natural History is presumably from Illinois. Another humpbacked specimen, from 3½ miles south of Batavia, Kane County, is in the collection of the Chicago Academy of Sciences.

Habits.—The spiny softshell and the smooth softshell are the most highly adapted of all Illinois reptiles for an aquatic existence. Nevertheless, both species enjoy basking, and at times a particularly favorable sand bar may be lined with these animals. It is almost impossible to stalk these alert turtles successfully and, once they are alarmed, it is difficult to overtake them. They run with great speed and appear to swim even faster. Both species of softshells have a habit of burying themselves in sand at the very margin of a stream. Inconspicuous craters mark the site where a turtle is buried, and occasionally the animal, when it needs air, may be seen to push its snout above sand and water. Anal and pharyngeal respiration enable softshells to remain submerged for long periods. Captured individuals are agile and extremely vicious.

In late November I have seen these turtles swimming in central Illinois. My observations are probably exceptional, inasmuch as Cahn (1937) reported that individuals buried themselves in mud or sand in late October to remain until May.

The spiny softshell is carnivorous, capturing and eating various aquatic animals.

Egg laying in this turtle, according to Cahn (1937), is slow and deliberate; the female is always alert for danger. The eggs are laid in sand or other soil, which the female may moisten with discharges of cloacal water. The eggs are carefully covered and concealed in the manner of other turtles. Nine to 25, averaging 18, spherical, hard-shelled eggs are laid in June. The eggs are 28 to 29 mm. in diameter. Hatchlings are in evidence by late August.

Illinois Distribution.—The spiny softshell occurs commonly throughout Illinois, fig. 140; records are not numerous, because this turtle is difficult to collect unless a special effort is made. *T. s. spinifer* has a much greater ecological tolerance than *T. m. muticus*, as it can be found in lakes, sloughs, and mud-bottomed streams as well as in sand-bottomed rivers. The spiny softshell is apparently most abundant in the last type of habitat.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols. BOONE COUNTY: Belvidere (Cahn 1937); BUREAU COUNTY: Bureau (Cahn 1937); CASS COUNTY: Chandlerville (Cahn 1937); CLAY COUNTY: Louisville (Cahn 1937); COOK COUNTY: Chicago (Schmidt & Necker 1935); Evanston (Necker 1939c); FAYETTE COUNTY: Vandalia (Cahn 1937); GRUNDY COUNTY: Morris (Stille & Edgren 1948); HANCOCK COUNTY: Hamilton, between Hamilton and Warsaw (Stejneger 1944); JACKSON COUNTY: Carbondale (Cagle 1942a); Elkhaville (Conant & Goin 1948); KANE COUNTY: Aurora (Stille & Edgren 1948); KANKAKEE COUNTY: Alton Mills (Necker 1939c); Aroma Township, Mokence (Schmidt & Necker 1935); LAKE COUNTY: Fox Lake (Cahn 1937); LA SALLE COUNTY: Streator (Cahn 1937); McHENRY COUNTY: McHenry (Stille & Edgren 1948); MACON COUNTY: Decatur (Cahn 1937); MADISON COUNTY: (Stejneger 1944); OGLE COUNTY: Oregon (H.



Fig. 140.—Distribution of *Trionyx spinifer*. Vertical hatching indicates the presumed range of the subspecies *spinifer* in Illinois; cross-hatching, the area of intergradation between the subspecies *spinifer* and *hartwegi*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Garman 1892); RANDOLPH COUNTY: Chester (Cahn 1937); ROCK ISLAND COUNTY: Barstow, Hillsdale, Rock Island (Cahn 1937); STEPHENSON COUNTY: Freeport (Cahn 1937); UNION COUNTY: Bluff Lake (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WHITE-SIDE COUNTY: Sterling (Cahn 1937); WINNEBAGO COUNTY: Rockton (Cahn 1937).

Order SQUAMATA Suborder SAURIA

Lizards

Six species of lizards are known to inhabit Illinois. Four additional species are included in the key, inasmuch as they may

eventually be found in extreme western Illinois.

The Illinois lizards are essentially diurnal animals. Some are strictly terrestrial; others are arboreal as well as terrestrial. They range in size from the 3-inch ground skink to the yard-long joint snake. All are predatory and partially or exclusively insectivorous.

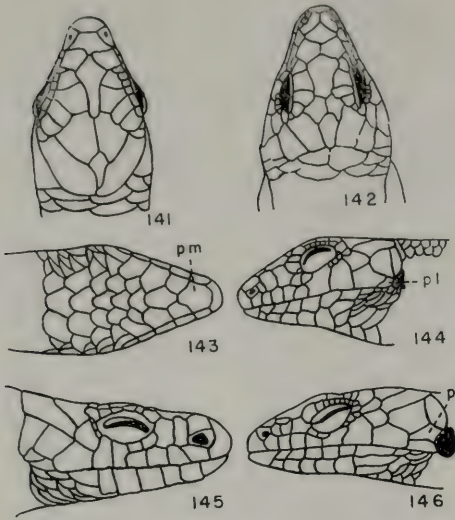
The tail, in all of the Illinois species of lizards, is readily broken off when this appendage is seized by a predator. This protective mechanism is best developed in the joint snake, whose tail comprises approximately two-thirds of its entire length. It is probably least developed in the racerunner, whose speed provides its best protection. The tail twitches violently for a time after it has been detached from the lizard, and in many cases the lizard escapes while the tail occupies the attention of the predator. The tail is eventually regenerated. The broken-off part is never reattached by the lizard, as is sometimes supposed.

Most lizards have a rather simple courtship before mating. Typically, the elongate, membranous-shelled eggs are deposited in early summer under objects or within logs where desiccation is unlikely. In some species the female remains with the clutch and may even attempt to protect the eggs. The young hatch in late summer. The attainment of sexual maturity requires at least 2 years. The longevity of the Illinois species is unknown.

Three of the six Illinois species occur principally in southern United States and have ranges extending northward for varying distances into or beyond Illinois. Another species, *Ophisaurus attenuatus*, also principally southern in distribution, has a subspecies, clearly a western element, extending into Illinois and northern Indiana via the Prairie Peninsula. One species, *Eumeces fasciatus*, is essentially a lizard of eastern North America; one, *Cnemidophorus sexlineatus*, is not readily assignable.

Key to Suborder Sauria (Lizards)

1. Legs absent; a lateral groove on each side of body extending from neck to anus (Anguidae) 2
- Legs present; no lateral grooves 2
2. White markings in middle of scales; usually a distinct middorsal stripe; scale



Figs. 141-146.—Characteristics of lizards: 141, head of *Scincella laterale*; 142, head of *Eumeces*; 143, chin of *Eumeces anthracinus*, showing single postmental (pm) scale; 144, head of *Eumeces laticeps*, showing single postlabial (pl) scale; 145, head of *Eumeces septentrionalis*; 146, head of *Eumeces fasciatus*, showing two subequal postlabial scales.

No postnasal scale, fig. 145; conspicuous dorsolateral light stripe.....
Eumeces septentrionalis septentrionalis
 9. One or no postlabials, fig. 144; usually 8 supralabials on each side.....
Eumeces laticeps
 Two subequal postlabials, fig. 146; usually 7 supralabials on each side.....
Eumeces fasciatus

IGUANIDAE

Twelve genera of this family occur in the United States and Canada. Although this family is essentially New World in distribution, a few genera are known on Madagascar and on certain islands in the Pacific. One genus, *Sceloporus*, is represented in Illinois; a second genus, *Crotaphytus*, may eventually be found in the state.

Sceloporus Wiegmann

Fourteen species, most of which consist of several subspecies, of this North American genus occur in the United States. One form enters Illinois.

Sceloporus undulatus hyacinthinus (Green)

Northern Fence Lizard Swift

Lacerta hyacinthina Green 1818:349 (type locality: probably Princeton, New Jersey).
Sceloporus undulatus hyacinthinus, P. W. Smith 1947:32.
Sceloporus undulatus undulatus nec Latreille, Yarrow 1882a:59-60.
Sceloporus undulatus, S. Garman 1883:xiv.
Sceloporus undulatus fasciatus, McCauley 1945:31.

Diagnosis.—A moderately stout lizard (largest Illinois specimen 190 mm. in total length), fig. 147, with rough, overlapping scales, each of which has a backwardly projecting spine; 40 to 50 scales around middle of body; 36 to 44 scale rows between occiput and point above hind legs; ventral scales similar to dorsals but smaller; femoral pores 12 to 16 on each side; usually 5 to 8 undulating, transverse brown or black bands on a gray or light brown groundcolor.

Variation.—The adult male in this species differs from the female in having a stouter tail proximally, more prominent femoral pores, and conspicuous gular and latero-ventral blue patches.

- rows 1 and 2 of venter usually with thin, longitudinal dark stripes.....
Ophisaurus attenuatus attenuatus
 White markings on posterior corner of scales; no distinct middorsal stripe; no dark stripes on venter.....
Ophisaurus ventralis
 3. Scales strongly keeled (Iguanidae).....
Sceloporus undulatus hyacinthinus
 Scales not keeled.....4
 4. Scales above granular.....5
 Scales above large, smooth, and imbricate (Scincidae).....6
 5. Venter with large transverse plates; dorsum with six light longitudinal stripes (Teiidae).....
Cnemidophorus sexlineatus sexlineatus
 Venter without large transverse plates; a distinct black collar on the neck (Iguanidae).....
Crotaphytus collaris collaris
 6. Frontonasals contacting rostral, fig. 141; maximum snout-vent length $1\frac{1}{2}$ inches.....
Scincella laterale
 Frontonasals separated from rostral by a pair of supranasals, fig. 142; maximum snout-vent length 5 inches..... 7
 7. One large postmental, fig. 143; pronounced, lateral dark stripe 2 scale rows wide... *Eumeces anthracinus pluvialis*
 Two postmentals; lateral dark stripe, if present, poorly defined.....8
 8. Postnasal scale present, fig. 144; dorsolateral light stripe, if present, no more pronounced than middorsal light stripe..... 9

The subadult is proportionately shorter tailed and, like the adult female, usually lacks the blue gular and lateroventral belly patches. The femoral pores are inconspicuous in the juvenile.

No important trends in geographic variation have been discerned for this species

within the state. A slightly higher frequency of males with gular spots fused is suggested for lizards from the extreme southern tip of the state. Other trends in geographic variation are summarized in table 44.

Habits.—The northern fence lizard, or swift, is ordinarily a conspicuous reptile in



Fig. 147.—An adult *Sceloporus undulatus hyacinthinus* from Jackson County, Illinois. The groundcolor is gray, tan, or light brown; the markings are dark brown or almost black.

Table 44.—Geographic variation in Illinois *Sceloporus undulatus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SHAWNEE HILLS (20)		LOWER MISSISSIPPI BORDER (12)		SOUTHERN DIVISION (20)	
	Range	Mean	Range	Mean	Range	Mean
Snout-vent length (mm.).....	38-73	.....	36-76	.....	51-82	.....
Total length (mm.), maximum.....	173	.....	174	.....	190	.....
Dorsal scale rows.....	36-44	40	36-43	40.5	36-42	39.4
Scale rows at mid-body.....	40-48	43.3	40-50	44.8	40-49	43.8
Femoral pores on both sides.....	24-32	28.5	24-30	25.2	25-31	28.4
Transverse body bands.....	5-9	6.3	5-8	6.9	6-8	6.6

open, dry, wooded areas, such as rocky hill-sides or wood lots. This lizard frequently is found in the vicinity of fallen trees, stumps, and rail fences, and often it is heard

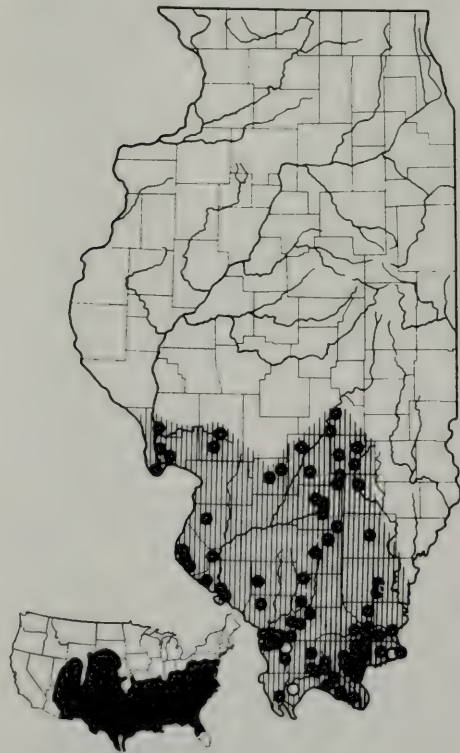


Fig. 148.—Distribution of *Sceloporus undulatus*. Hatching indicates the presumed range of the subspecies *hyacinthinus* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

scampering over bark before it is seen. It climbs readily and is usually alert, managing to be on the side of a limb or tree trunk opposite the pursuer. When undisturbed, this lizard may be seen flattened against a limb or rock and basking in the sun. During cold or rainy weather, it seeks shelter under bark, logs, or rocks. While hunting food, the northern fence lizard has a rather jerky locomotion and stops at intervals to do “push-ups” with its front legs. Its food consists of insects and other arthropods, ants being especially relished (Cagle 1945).

Copulation in the northern fence lizard occurs in late April and early May. Gravid females deposit elongate, soft-shelled eggs within rotten stumps or under the bark of decaying logs. Cagle (1942a) found that 8 eggs laid the first of August by a female in southern Illinois averaged 7.5×13.5 mm. Hatchlings are generally abundant by the last of August.

Illinois Distribution.—Fence lizards occur throughout the southern part of Illinois except for the Wabash Border division, fig. 148. Their occurrence becomes increasingly local toward the northern edge of the range, suggesting that temperature may be one of the important limiting factors. Where they occur, they are abundant; their avoidance of Wabash River counties in Illinois and Indiana is not readily explained.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: HARDIN COUNTY: Cave in Rock (H. Garman 1892); PULASKI COUNTY: Villa Ridge (H. Garman 1892); UNION COUNTY: Cobden (H. Garman 1892).

Crotaphytus Holbrook

This strictly North American genus contains four species, according to some authors, five, according to others. Two or three, the number depending on the point of view of the specialist, species occur in the United States, and one of these is known from the Mississippi River bluffs in Missouri but is not known in Illinois.

Crotaphytus collaris collaris (Say) Eastern Collared Lizard

Agama collaris Say 1823:252 (type locality: Verdigris River near its union with the Arkansas River, Oklahoma).

Diagnosis.—A large iguanid lizard with a broad head distinctly set off from the body by a narrow neck; tail approximately twice as long as snout-vent length; granular scales above, slightly larger scales below; femoral pores present; a distinct black nuchal collar, which is interrupted medially.

Distribution.—A colony of eastern collared lizards at Pevely, Missouri, which is on the Mississippi River bluffs opposite Valmeyer, Monroe County, Illinois, was known to Hurter (1897). This population still exists. I have thus far been unable to find the species on the Illinois side of the river, but there is a slight possibility that a small colony may occur somewhere in the Monroe County bluffs.

ANGUIDAE

Opinion is divided among American herpetologists on the number of anguid genera in the United States, some authors recog-

nizing two and others four. The family is predominantly New World in distribution, but a few genera occur in Eurasia and Africa.

Ophisaurus Daudin

Three species of *Ophisaurus*, one with two subspecies, occur in the United States. Other species are found in the Old World. The nominate race of the polytypic species occurs over most of Illinois. One other species may be found in the state, although it is as yet unrecorded here.

Ophisaurus attenuatus attenuatus Cope Western Slender Glass Lizard Joint Snake

Ophiosaurus ventralis attenuatus Cope 1880: 18 (type locality: Dallas, Texas).

Ophisaurus attenuatus attenuatus, Schmidt 1953:138.

Ophisaurus lineatus, Kennicott 1855:591.

Ophiosaurus ventralis nec Linnaeus, Yarrow 1882a:46.

Ophisaurus ventralis nec Linnaeus, Hay 1887a: 14.

Ophisaurus ventralis ventralis nec Linnaeus, Cope 1900:500.

Ophiosaurus ventralis nec Linnaeus, Gaige 1914:4.

Remarks.—Although most authors, since the species' rediscovery, and a check list (Schmidt 1953) credit the name *attenuatus* to Baird rather than to Cope, it is clear that Cope validated the name and is actually the author. Dallas, Texas, automatically becomes the type locality.

Diagnosis.—A limbless lizard (largest Illinois specimen 726 mm. in total length), fig. 149, with a distinct, dark middorsal stripe; white markings primarily in the mid-

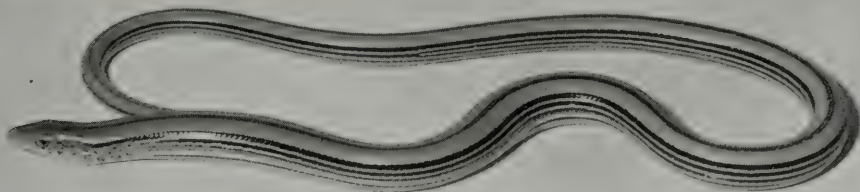


Fig. 149.—An adult *Ophisaurus attenuatus attenuatus* from Harris County, Texas. The groundcolor is greenish gray, tan, or light brown; the stripes are brown or dark gray. (Photo by Isabelle Hunt Conant). Some adults from Illinois have numerous dark and light flecks on the dorsum and are less distinctly striped than the lizard pictured here.

dle of the scales, often forming longitudinal light stripes; 1 or 2 dark stripes or rows of dark spots below the lateral line on each side of body; and length of the unregenerated tail of the adult less than 2.4 times the snout-vent length.

Variation.—The male of the western slender glass lizard presumably possesses a thicker tail proximally than the female, but external characters are not reliable for distinguishing the sexes. The juvenile apparently differs from the adult only in size.

No geographic variation has been discerned in the meager sample available. Nine specimens yield the following individual variation: snout-vent length 164 to 304 mm.; body length 30 to 33 per cent of total length; ventral scales 127 to 138 (average 130.7); supralabials 9 + 9 to 11 + 12, usually 10 or 11; infralabials 8 + 8 to 11 + 10, usually 9 + 9. Eighty-eight per cent of the specimens have distinct, dark middorsal stripes; 22 per cent possess weak middorsal bands. The two largest specimens possess prominent light markings on the posterior edges of the dorsolateral scales, as well as confluent light lines through the middle of the scales; the remaining seven specimens exhibit only the light lines. One specimen, from Perry County, lacks the ventral rows of spots, two specimens have a single row on each side, four have a double row, and two have three rows. A specimen from Champaign County has a double tail.

Habits.—The snakelike ophisaur is terrestrial and somewhat fossorial. Little is known of its habits in Illinois, aside from the generally known fragility of its long tail. Captives are nervous; those I have kept refused all food offered. A captive specimen of the related *Ophisaurus ventralis* ate other lizards, small snakes, and crickets, and it is likely that food habits are similar in the two species. Captured individuals do not usually bite, but they must be held gently or the brittle tail will fragment.

No information is available for eggs or hatchlings of this lizard in Illinois.

Illinois Distribution.—This lizard is inexplicably rare in Illinois, fig. 150. It is interesting to note that Garman (1892) believed the species was rapidly being exterminated within the state. Today, almost 70 years later, the same observation might be made; nevertheless, specimens are still found in Champaign County, one of the

most intensively cultivated regions in Illinois.

Several specimens have been collected in narrow strips of prairie bordering railroads. Judged from reports, the western slender

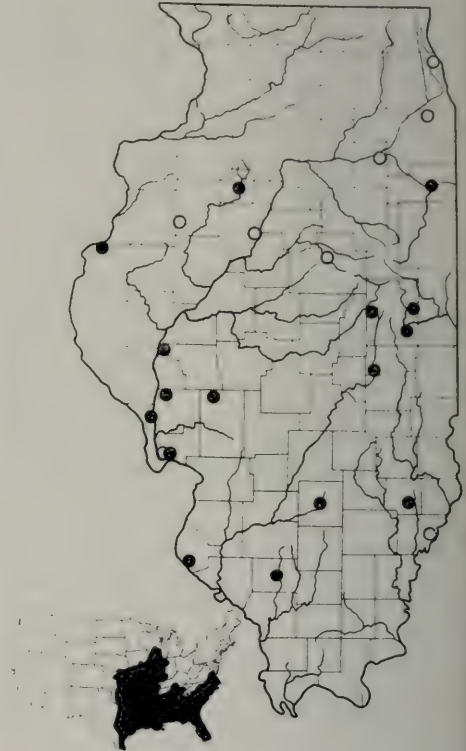


Fig. 150.—Distribution of *Ophisaurus attenuatus*. The subspecies *attenuatus* apparently occurs throughout the state, although it is rare in all sections. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

glass lizard is more common in the dissected hills of Calhoun and Pike counties than elsewhere in the state. In Illinois *Ophisaurus* does not seem to be more common in the sand prairies than on other soil types, as it is in Indiana.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Evanston, Palos Park (Schmidt & Necker 1935); GRUNDY COUNTY: Pequot (Stille & Edgren 1948); JERSEY COUNTY: Pere Marquette State Park (Link 1939);

KNOX COUNTY: Abingdon (McLain 1899); McLEAN COUNTY: Normal (H. Garman 1892); PEORIA COUNTY: Peoria (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882a).

***Ophisaurus ventralis* (Linnaeus)**
Eastern Glass Lizard

Anguis ventralis Linnaeus 1766:391 (type locality: Carolina; revised to vicinity of Charleston, South Carolina, by Neill 1949c).
Ophisaurus ventralis, McConkey, 1952:2.

Diagnosis.—A limbless lizard, differing from *Ophisaurus attenuatus* in the following characters: white marking occurring on posterior corner of each scale rather than in middle of scale; no distinct middorsal dark stripe; ventral region without dark stripes or rows of dark spots.

Distribution.—*O. ventralis* is a southeastern species, said to occur northward to southern Illinois (McConkey 1952). No Illinois specimens are extant, but there is an authentic record for it in adjacent St. Louis County, Missouri.

TEIIDAE

The center of distribution of this family is South America. It is represented in North America by one widely distributed genus.

***Cnemidophorus* Wagler**

Ten species of *Cnemidophorus*, several of which consist of two or more subspecies,

occur in the United States, but only one inhabits Illinois.

***Cnemidophorus sexlineatus sexlineatus* (Linnaeus)**

Six-Lined Racerunner Whiptail Lizard

Lacerta sexlineata Linnaeus 1766:364 (type locality: Carolina; revised to Charleston, South Carolina, by Schmidt 1953).

Cnemidophorus sexlineatus, Jordan 1878:171.

Cnemidophorus sexlineatus sexlineatus, Burt 1931:76-97.

Cnemidophorus sex-lineatus, Hay 1887a:14.

Diagnosis.—A medium-sized, slender lizard (largest Illinois specimen 240 mm. in total length), fig. 151, having granular scales above and 32 to 36 rows of enlarged rectangular scutes below; 2 gular folds; olive, gray, brown, or gray-green ground-color with 6 longitudinal, narrow light stripes extending onto the base of the tail.

Variation.—In this species the male differs from the female in having more conspicuous femoral pores, a heavier tail proximally, less distinct, lateral light stripes, and the frequent presence of a pale blue wash ventrally.

Juveniles are shorter tailed than adults. In five young specimens less than 45 mm. from snout to vent, the snout-vent length comprises 32.1 to 38.5 (average 35.8) per cent of the total length, whereas in eight adult females the range is 30.6 to 35.7 (average 32.4) and in eight adult males 30.3 to 34.2 (average 31.9).

Six-lined racerunners appear to attain their maximum size in extreme southeastern



Fig. 151.—An adult *Cnemidophorus sexlineatus sexlineatus* from Tazewell County, Illinois. The groundcolor ranges from olive-gray to brown, often with green on the fore part of the body; the dark stripes are dark gray, brown, or almost black; the light stripes are green, gray, or dirty yellow.

Illinois. In a series from Brookport, Massac County, four adults range from 70 to 79 mm. in snout-vent length. Elsewhere in the state the largest specimens seldom exceed 70 mm. in snout-vent length.

No other geographic variation trends are evident. Scutellation data for 26 specimens are as follows: femoral pores 14 to 19, usually 17, per side; transverse rows of ventral plates between second gular fold and anal plates 30 to 36, average 33.8; lamellae under fourth toe 21 to 29, average 25.2.

Habits.—These strictly terrestrial lizards are sun-loving, and on hot, sunny days they are quite conspicuous. On dull or cool days they seek shelter in holes or beneath objects. Whiptails are alert and fast, and shooting is the most profitable collecting technique. The food consists of arthropods.



Fig. 152.—Distribution of *Cnemidophorus sexlineatus*. Hatching indicates the presumed range of the subspecies *sexlineatus* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Eggs of this lizard have been found in late June. The eggs, 3 to 5 to a clutch, were in scooped-out hollows in moist sand beneath railroad ties. Hatchlings are in evidence by late July.

Illinois Distribution.—The racerunner, or whiptail lizard, occurs on hill prairies, in all the major sand areas, and also in the extreme southeastern part of Illinois, fig. 152. It is possible that it may be found also in some of the minor sand areas and in all the counties bordering the Mississippi River.

Along the Mississippi River bluffs this species appears to be restricted to the dry hill prairies and is seldom found at the bases of the bluffs. It is most abundant in sand prairies and it shuns woods, wet soil, and soil rich in humus.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Forest Preserves (Pearsall 1940); HARDIN COUNTY: Cave in Rock (H. Garman 1892); LA SALLE COUNTY: Ottawa (H. Garman 1892); MASON COUNTY: 10 mi. N Havana (Hart & Gleason 1907); TOPEKA (Burt 1931); ST. CLAIR COUNTY: Bluff Lake (Hurter 1893).

SCINCIDAE

Three genera of this world-wide family of lizards occur in the United States and Canada. Two are represented in Illinois.

Scincella Mittleman

One monotypic species occurs in eastern United States. Currently most authors regard *Scincella* as a subgenus of the widely distributed *Lygosoma*.

Scincella laterale (Say) Ground Skink

Scincus lateralis Say 1823:324 (type locality: banks of the Mississippi River below Cape Girardeau, Missouri).

Oligosoma lateralis, S. Garman 1884:14.

Oligosoma laterale, Jordan 1878:171.

Lygosoma laterale, Moore 1896:752.

Liopisisma laterale, Cope 1900:624.

Leiopisisma laterale, Surface 1907:251.

Leiopisisma laterale, Schmidt & Necker 1935:60.

Leiopisisma unicolor, Stejneger & Barbour 1939:86.

Leiopisisma unicolor, Brimley 1941:14.

Diagnosis.—A small, slender, lizard (largest Illinois specimen 131 mm. in total length), fig. 153, with 24 to 30 rows of smooth scales around the middle of the body; 59 to 74 dorsal scales in a line between the parietal and a point above the hind legs; frontal scale V-shaped; a window in the lower eyelid; a dorsal groundcolor of

tan, light brown, or copper, with distinct, dark chestnut dorsolateral bands; supranasals absent.

Variation.—In the ground skink, the sexes presumably differ in the heavier tail of the male, but external characters are not reliable for sexing specimens.

Newly hatched lizards appear propor-



Fig. 153.—An adult *Scincella laterale* from Jefferson County, Missouri. The groundcolor is tan or light brown; the lateral bands and dorsal flecks are dark brown. Some specimens, particularly subadults, are distinctly copper colored above.

tionately shorter tailed and longer legged than adults. In nine juveniles less than 40 mm. from snout to vent, the legs, when adpressed, overlap or are separated by as much as 8 scale lengths (average 3.1). In nine adults, the toes of the adpressed limbs are separated by 13 to 24 scale lengths (average 15.5). However, the proportionately shorter tail of the young is not evident in subadults, inasmuch as the tail comprises approximately 60 per cent of the total length of all the available specimens 25 mm. or more in snout-vent length.

No geographic variation in this species has been discerned within the state. Twenty specimens at hand vary as follows: snout-vent length 24 to 49 mm.; total length 61 to 131 mm.; scale rows at mid-body 24 to 29 (average 26.3); dorsal scales between parietal and point above the hind legs 59 to 74 (average 67); supralabials 5 + 6 to 7 + 7 (7 + 7 in 90 per cent of specimens); infralabials 6 + 6 to 7 + 7 (6 + 6 in 60 per cent of specimens); lamellae under fourth toe 14 to 17 (average 15.3). Thirty-seven per cent of the specimens are plain brown above, 47 per cent have a tendency toward having 2 longitudinal rows of dark spots, and 16 per cent are variously flecked with dark markings.

H. Smith (1956) gives the range of dorsal scales as 77 to 80. The source of his counts is presumed to be Kansas specimens.

Habits.—This small, terrestrial lizard is inconspicuous in appearance. On numerous occasions, specimens would have been missed if they had not rustled leaves on the ground as they ran. Their movements are quick and jerky. When pursued ground skinks burrow into the leaf mold. They have been encountered at night several times. An active individual was once found in February. The food of the ground skink consists of small, soft-bodied arthropods.

A captive specimen laid 5 eggs on June 21–22. At the time the eggs were laid, their dimensions averaged 8.6×5.1 mm. In a few days the average size was 8.6×6 mm., but the eggs spoiled soon thereafter. Eggs in natural nests have been found in rotten logs in July. Hatchlings are abundant by late August.

Illinois Distribution.—The ground skink is abundant in wooded regions of the Shawnee Hills and Lower Mississippi Border counties, fig. 154. Widely scattered colonies

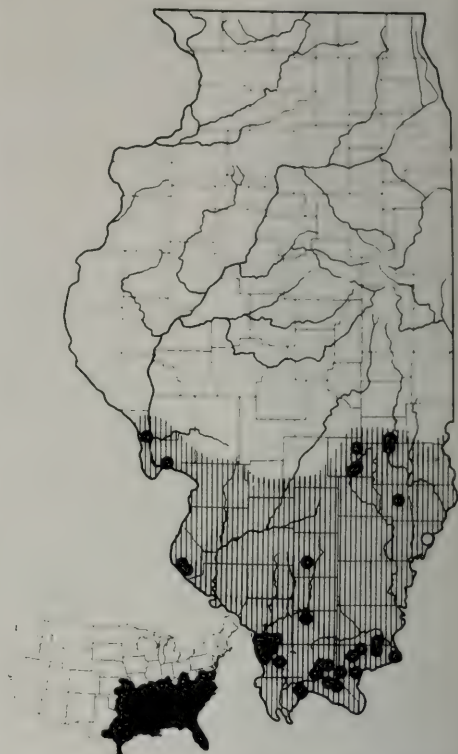


Fig. 154.—Distribution of *Scincella laterale*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

are known as far north as Calhoun and Cumberland counties; numerous areas between, which appear to be suitable, are seemingly uninhabited. The northern colonies are in dry, wooded habitat; rocks are not requisite for the occurrence of *Scincella*.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: WABASH COUNTY: Mount Carmel (Cope 1900).

Eumeces Wiegmann

Fourteen species of this genus, a few consisting of several subspecies, occur in the United States and Canada. The genus is almost world-wide in distribution. Two species are known to inhabit Illinois and two others may eventually be found in the extreme western part of the state.



Fig. 155.—An adult female *Eumeces fasciatus* from Monroe County, Illinois. Young specimens are black with narrow yellowish white lines and brilliant blue tails; subadult males and adult females are dark brown with light gray stripes. Adult males are bronzy brown with little trace of the striped pattern and have conspicuously reddened jowls.

Eumeces fasciatus (Linnaeus)
Five-Lined Skink

- Lacerta fasciata* Linnaeus 1758:209 (type locality: Carolina; revised to Charleston, South Carolina, by Schmidt 1953).
Plestiodon fasciatus, Kennicott 1855:591.
Eumeces fasciatus, Schneek 1880b:55.
Plestiodon quinquelineatus, Kennicott 1855:591.
Eumeces quinquelineatus, Cope 1900:639-40 (?part).
Eumeces sp., Mertens 1951:15.

Diagnosis.—A small to medium-sized lizard (largest Illinois specimen 190 mm. in total length), fig. 155, with 26 to 30 smooth, subequal scales around the mid-body; 50 to 54 dorsal scales between the occiput and a point above the hind legs; frontal scale rectangular; pattern of 5 longitudinal light stripes on dark background, except in sexually mature males, which are tan, gray, or bronze, with red jowls; juveniles and subadults with blue tails; two postmental scales and a postnasal scale on each side of head; usually 7 + 7 supralabials; 2 subequal postlabials, fig. 146. Key characters of this species and a similar species, *Eumeces laticeps*, are graphed in fig. 156.

Variation.—The adult male in this species is almost unicolorous above, with red or coppery color on the swollen jowls; the adult female retains the striped juvenile pattern, although the lines are often dim. The base of the tail and the temporal region are conspicuously larger in the male.
Newly hatched skinks are shiny black, with distinct light stripes and a brilliant blue tail, which is proportionately shorter than in adults. The subadult loses the blue

color of the tail and much of the contrast between stripes and groundcolor.

Individual variation within a series from one locality at least equals any geographic variation in Illinois. Scutellation data for two samples are summarized in table 45.

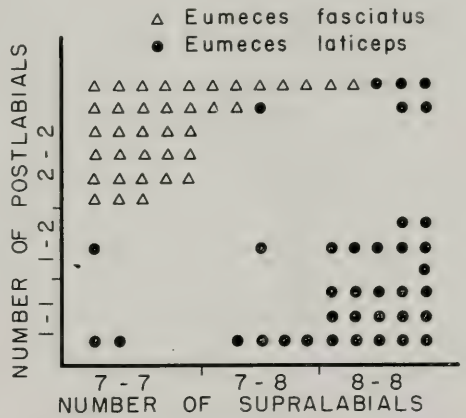


Fig. 156.—Scattergram showing number of supralabials plotted against number of postlabials in *Eumeces fasciatus* (hollow symbol) and *Eumeces laticeps* (solid symbol).

Habits.—The five-lined skink is often seen on sunny days around abandoned buildings, rotten logs, dead trees, and rock outcrops, but it can be collected in numbers only by raising rocks or logs, or ripping apart rotten stumps. The species is much less conspicuous than the northern fence lizard. The two species are equally abundant in the southern half of Illinois. Both open and dense wooded areas appear to provide ideal habitat for five-lined skinks. These

Table 45.—Geographic variation in Illinois *Eumeces fasciatus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (20)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (20)	
	Range	Mean	Range	Mean
Scale rows at mid-body.....	25-30	28.9	26-30	28.4
Dorsal scale rows.....	50-55	52.9	52-55	53.0
Subdigital lamellae on fourth toe.....	15-19	16.8	15-18	16.6
Snout-vent length (mm.).....	34.0-82.8	.....	35.5-82.0	.....
Total length (mm.), maximum.....	195	.....	187	.....

skinks are quick and difficult to capture, but usually they are not so alert as fence lizards. Captured specimens try to bite, and often their tails are broken off unless the animals

are handled carefully. The food of these skinks consists primarily of arthropods, although instances of predation on annelids, mollusks, and vertebrates have been reported.

Egg clutches of the five-lined skink, attended by the female, are to be found in rotten logs or stumps in July. Eggs laid by a captive specimen averaged 13 × 7.8 mm.; the eggs increase in size as they develop, and those found in natural nests average 13.5 × 10 mm. The clutch size in southern Illinois ranges from 6 to 15, averaging about 9 per nest (Cagle 1940). Oviposition occurs in late June, and hatchlings are to be found by late July.

Illinois Distribution.—The five-lined skink occurs throughout the southern half of Illinois, fig. 157. It is known in the Northeastern Mesic Forest, and scattered colonies may occur along the Mississippi and Illinois rivers. North of the Shelbyville Moraine this species is very rare and probably does not occur at all throughout the Grand Prairie region.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: LAKE COUNTY: Waukegan (Cope 1900).

Eumeces laticeps (Schneider)
Broad-Headed Skink

Scincus laticeps Schneider 1801:189 (type locality: not stated; designated as Charleston, South Carolina, by Schmidt 1953).
Eumeces laticeps, Taylor 1935:212-24.
Plestiodon quinquelineatus, Kennicott 1855: 591 (?part).
Eumeces quinquelineatus, Cope 1900:639-40 (?part).

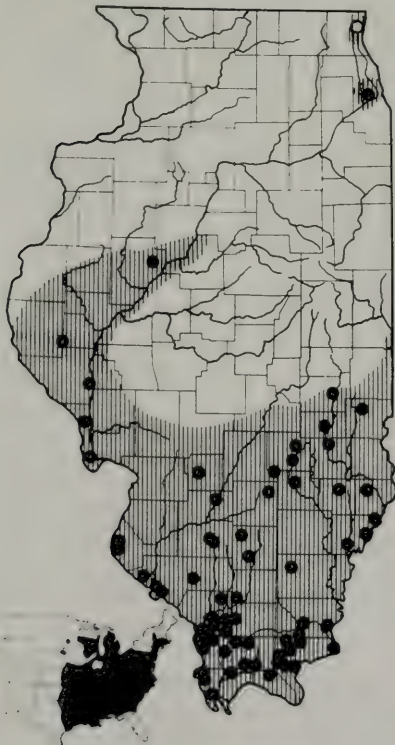


Fig. 157.—Distribution of *Eumeces fasciatus*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States. The species avoids prairie areas.

Eumeces fasciatus nec Linnaeus, Yarrow 1882a:42 (?part).
Eumeces obsoletus nec Baird & Girard, Davis & Rice 1883a:31.
Scincus erythrocephalus, H. Garman 1892: 257-9 (?part).
Eumeces sp., Mertens 1951:15.

Diagnosis.—A large skink (largest Illinois specimen 260 mm. in total length), fig. 158, differing from the five-lined skink in the usual presence of 8 + 8 supralabials (usually 5 preceding subocular), 1 + 1 postlabials, fig. 144, slightly higher average number of scale rows at mid-body, and its larger size.

Variation.—Sexual and ontogenetic variation in *Eumeces laticeps* parallels that in *E.*

fasciatus. Scutellation data for three samples are summarized in table 46.

Habits.—This large Illinois skink is similar in habits to *E. fasciatus*. It is reportedly more arboreal, however, and the Illinois observations bear out the report. It is occasionally seen high in trees, particularly in dead trees with numerous woodpecker holes. On the ground it is agile and quick. Captives are quick to bite, and their jaws are strong enough to inflict an uncomfortable pinch. Specimens have been observed at the edges of wood lots, where they were feeding on grasshoppers. These lizards probably feed on almost any animal they can overpower.



Fig. 158.—An adult male *Eumeces laticeps* from Coles County, Illinois. Young specimens are black with yellowish white lines and blue tails; subadult males and adult females, dark brown with light gray stripes; adult males are bronzy brown with little trace of the striped pattern and have conspicuously reddened jowls.

Table 46.—Geographic variation in Illinois *Eumeces laticeps*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (12)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (21)		ROCK ISLAND COUNTY(1)
	Range	Mean	Range	Mean	
Scale rows at mid-body.....	27-32	29.5	27-33	29.5	30
Dorsal scale rows.....	50-56	53.1	51-55	52.4	56
Subdigital lamellae on fourth toe.....	16-18	17.1	15-18	16.6	17
Snout-vent length (mm.).....	40.5-97.8		33.0-116.8		64
Total length (mm.), maximum.....	225		260		

Almost nothing is known of the nesting habits of the species in Illinois. A female was found coiled around her eggs in a stump on July 4; the eggs were not measured.

Illinois Distribution.—The broad-headed skink, like *E. fasciatus*, is common throughout the southern half of Illinois, fig. 159,



Fig. 159.—Distribution of *Eumeces laticeps*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

and extremely local in its occurrence north of the Shelbyville Moraine.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CUMBERLAND COUNTY: SE corner of county (Peters 1942); JACKSON COUNTY: Murphysboro (Taylor 1935); RANDOLPH COUNTY: Chester (Taylor 1935); Red Bud (Taylor 1935); ST. CLAIR COUNTY: Belleville (Taylor 1935).

Eumeces anthracinus pluvialis Cope Southern Coal Skink

Eumeces pluvialis Cope 1880:19, footnote (type locality: near Mobile, Alabama).

Eumeces anthracinus pluvialis, Smith & Smith 1952:690.

Diagnosis.—A medium-sized skink with a single postmental scale, fig. 143; 23 to 30 rows of smooth scales at mid-body; usually 7 + 7 supralabials; supranasal scales present but no postnasal scales; a distinct black or chestnut dorsolateral stripe on each side of body.

Range.—The southern coal skink is known in Missouri adjacent to Monroe County, Illinois, but efforts to secure specimens on the Illinois side of the Mississippi have thus far been unsuccessful. There is a possibility that a local population in the Illinois bluffs may eventually be found.

Eumeces septentrionalis septentrionalis (Baird) Northern Prairie Skink

Plestiodon septentrionalis Baird 1858:256 (type locality: Minnesota and Nebraska; revised to Fort Ripley, Minnesota, by Schmidt 1953).

Diagnosis.—A medium-sized skink with supranasal but no postnasal scales, fig. 145; two postmental scales; 26 to 28 rows of smooth scales at mid-body; conspicuous, light, dorsolateral stripe on each side of body bordered above and below by prominent, slightly wider dark bands; dim or prominent light middorsal line that does not fork.

Range.—The northern prairie skink is known from nearby Iowa and Wisconsin, and there is some possibility that populations occur in the northwestern corner of Illinois, in which little work has been done.

Suborder SERPENTES Snakes

Forty-six species and subspecies of snakes are known to occur in Illinois. Four of the species are represented not only by a population typical for a particular subspecies but by an adjacent intergrade population as well. Although these intergrade populations are not regarded as distinct entities they are included in the key.

Snakes are extremely variable in habits and structure. In general, the crotalids

(*Crotalus*, *Sistrurus*, and *Agkistrodon*) and natricines (*Natrix*, *Thamnophis*, *Storeria*, *Virginia*, and *Tropidoclonion*) are active day or night, and the colubrines (the remaining genera) tend to be diurnal. The majority of our genera are terrestrial; some are fossorial; a few are aquatic; still fewer are arboreal. In size, they range from the 10-inch *Tantilla gracilis* to the 7-foot *Pituophis melanoleucus*. Snakes are rather specialized in feeding habits, some taking only one or two specific types of prey. All of them are predatory. Some species swallow living prey; some swallow their prey after killing it by constriction and some (those that possess fangs) after using poison for procuring it.

One or more species of venomous snakes occur in all herpetofaunal divisions of Illinois, but there are many smaller areas of the state from which the poisonous snakes have been entirely eliminated. The dangerous species rank, according to the decreasing seriousness of their bites, as follows: timber rattler, cottonmouth, copperhead, and massasauga. Although bites of all four species have come to my attention in the course of this survey, I know of no deaths from snake bite in Illinois during this time. The copperhead is probably responsible for the greatest number of snake bites requiring medical attention.

Snakes usually mate in the spring of the year, although exceptions are known. Approximately half of the Illinois species lay elongate, membranous-shelled eggs; the other half retain their eggs within the body and give birth to active young. The former are called oviparous; the latter ovoviviparous. Typically, snake eggs are deposited under rocks or in wood rot. The hatching of the eggs of the oviparous species and the birth of young of the ovoviviparous species take place in late summer and early fall. The young snakes grow fairly rapidly and are probably sexually mature at an average age of 2 years. The young and adults shed their skins two to six times annually, the number of times depending on the rate of growth and state of health of the individual snake.

Most of the species and subspecies found in the state have the centers of their ranges outside of Illinois. Seventeen have distributions centering to the west and southwest,

the ranges of some (for example, *Tantilla gracilis*) being slight eastern extensions of ranges in the Ozarks of Missouri and Arkansas. Others (for example, *Heterodon nasicus*) are Great Plains animals with small relict populations in our sand prairies. Eleven forms have essentially southern ranges with northward extensions in the Mississippi River valley. Eight have ranges centering to the east of Illinois and one to the north; eight cannot be readily assigned to any of the above groups.

Key to the Suborder Serpentes
(Snakes)

- 1. No pit between eye and nostril, figs. 160, 161 (Colubridae) 7
- Pit between eye and nostril on each side of head, fig. 163 (Crotalidae) 2
- 2. Rattle on end of tail 3
- No rattle on tail 5
- 3. Top of head with large plates
 - Sistrurus catenatus catenatus*
 - Top of head with various-sized unsymmetrical scales 4
- 4. Dorsal scales usually in 23 rows; few or no elongated black dashes between body bands *Crotalus horridus horridus*
- Dorsal scale rows usually 25; many elongated black dashes between body bands *Crotalus horridus horridus* × *atricaudatus*
- 5. Scale rows 23, fig. 162; suboculars present; postorbital dark stripe absent 6
- Scale rows 25; suboculars absent; postorbital dark stripe present
 - Agkistrodon piscivorus leucostomus*
- 6. Dorsal pattern constrictions averaging 3 scale lengths in width or less; ventral spots pale *Agkistrodon contortrix contortrix* × *mokeson*
- Dorsal constrictions averaging 4 or 5 scale lengths in width; ventral spots in marked contrast to groundcolor
 - Agkistrodon contortrix mokeson*
- 7. Some or all dorsal scales keeled 8
- All scales smooth 38
- 8. Anal plate divided, fig. 164 9
- Anal plate entire, fig. 165 31
- 9. Rostral scale upturned and keeled, figs. 166, 167 10
- Rostral scale normal, fig. 160 12
- 10. Prefrontals in contact, fig. 166; posterior supralabials slightly higher than wide *Heterodon platyrhinos*
- Prefrontals separated by small scales, fig. 167; posterior supralabials about twice as high as wide 11
- 11. Dorsal body blotches usually more than 35 in males, more than 40 in females
 - Heterodon nasicus nasicus*
 - Dorsal body blotches usually less than 35 in males, less than 40 in females
 - Heterodon nasicus nasicus* × *gloydi*
- 12. Loreal present, fig. 168 14
- Loreal lacking, fig. 169 13

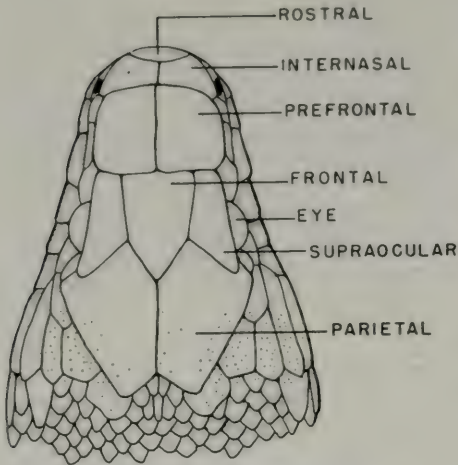


Fig. 160.—Dorsal view of the head of a snake, *Elaphe obsoleta*.

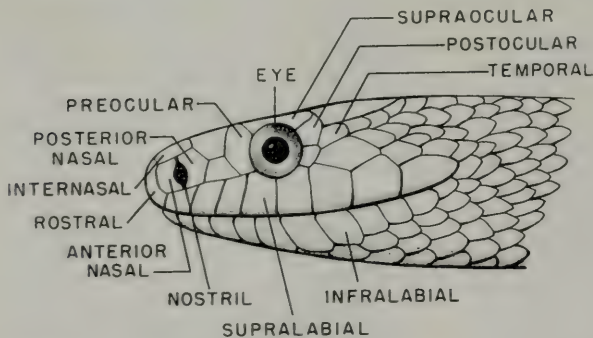


Fig. 161.—Lateral view of the head of a snake, *Elaphe obsoleta*.

13. Scale rows 15; light spots on rear of head; venter orange or red. *Storeria occipitomaculata occipitomaculata*
Scale rows 17; no occipital light spots; venter pink or white. *Storeria dekayi wrightorum*
14. Internasals 2, fig. 170. 17
Internasals 1, fig. 171. 15
15. Supralabials 6 or fewer on each side of head. 16
Supralabials 7 or more on each side of head. *Farancia abacura reinwardti*
16. Supralabials 6, postoculars 2 on each side of head. *Virginia valeriae elegans*
Supralabials 5, postoculars 1 on each side of head. *Virginia striatula*
17. Scale rows 17; dorsal color green. *Opheodrys aestivus*
Scale rows more than 17; dorsal color not green. 18
18. Scale rows strongly keeled; 2 or 3 postoculars (if 2, less than 25 scale rows). 22
Scale rows weakly keeled; 2 postoculars; 25–33 scale rows. 19
19. Neck bands traversing parietals and uniting on frontals. *Elaphe guttata emoryi*
Neck bands, if present, not as above. 20

20. Ventrals less than 220; dorsum tan or yellow, with brown blotches; venter yellow. *Elaphe vulpina vulpina*
Ventrals more than 220; dorsal groundcolor not yellow or tan; venter not yellow. 21
21. Dorsal scale rows 25–27; pattern in adults of evident black blotches on gray groundcolor. *Elaphe obsoleta spiloides*
Dorsal scale rows 25; pattern in adults solid black, or the groundcolor visible as tracery around blotches or as white patches between spots middorsally on the posterior portion of body. *Elaphe obsoleta obsoleta*
22. Scale rows 19. 23
Scale rows more than 19. 25
23. Infralabials 7; preoculars 1 on each side of head. *Natrix kirtlandi*
Infralabials 9 or more; preoculars 2 on each side of head. 24
24. Venter immaculate yellow or with 1 thin median stripe. *Natrix grahami*
Venter entirely dark brown or with two median stripes. *Natrix septemvittata*

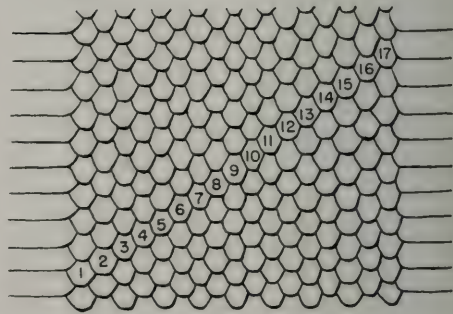
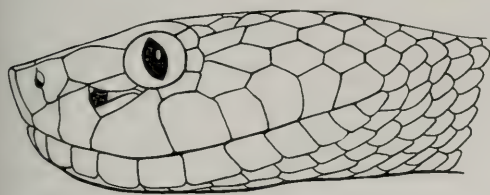


Fig. 162.—Portion of the body of a snake, illustrating method of counting scale rows. Counts are customarily made one head length behind the head, at approximately mid-body, and just in front of the anus.

25. Scale rows 27–33; infralabials 11 or more on each side of head. 26
Scale rows 25 or less; infralabials 10 on each side of head. 27

26. Suboculars separating eye from labials; venter predominantly dark, with light spots, fig. 172.....*Natrix cyclopion cyclopion*
 No suboculars, fig. 173; venter yellow, with dark spots.....*Natrix rhombifera rhombifera*
27. Venter unmarked, yellow or red..... 28
 Venter marked with brown or black spots or blotches..... 29

28. Ventral color red or red-orange, not touching first scale rows; dorsum black.....*Natrix erythrogaster neglecta*
 Ventral color yellow or orange-yellow, encroaching on lowermost lateral scale rows; dorsum brownish black.....*Natrix erythrogaster flavigaster*
29. Dorsal bands fewer than 20.....*Natrix sipedon confluens*
 Dorsal bands 20 or more..... 30



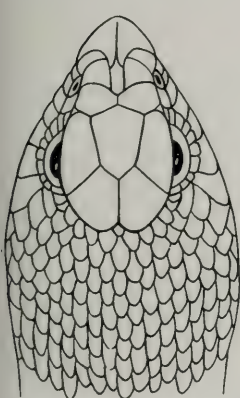
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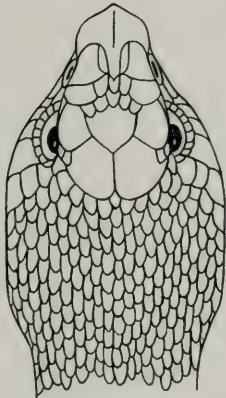
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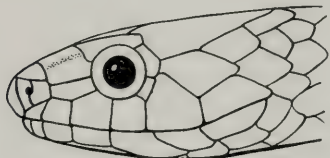
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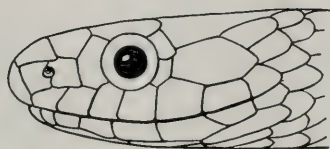
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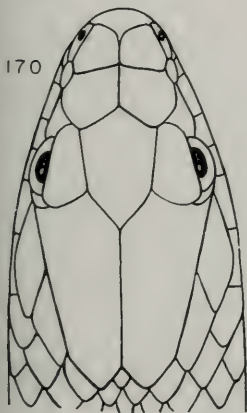
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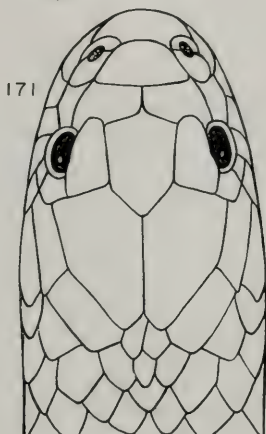
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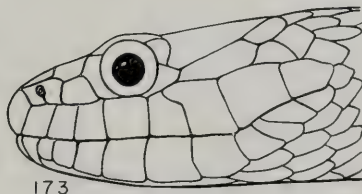
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171



172



173

Figs. 163-173.—Characteristics of snakes: 163, head of *Agkistrodon piscivorus*, showing loreal pit; 164, divided anal plate; 165, entire anal plate; 166, head of *Heterodon platyrhinos*; 167, head of *Heterodon nasicus*; 168, head of *Virginia valeriae*, showing elongate scale between eye and nostril that is termed loreal because its length is twice its height; 169, head of *Storeria dekayi*; 170, head of *Opheodrys vernalis*; 171, head of *Farancia abacura*; 172, head of *Natrix cyclopion*, showing suborbital scales; 173, head of *Natrix rhombifera*.

30. Dorsal bands and spots 30 or more; lateral bars wider than interspaces; anterior transverse bands 3 to 10
..... *Natrix sipedon sipedon*
Dorsal bands and spots less than 30; lateral bars narrower than interspaces; anterior transverse bands 5 to 15
..... *Natrix sipedon pleuralis*
31. Scale rows 27 or more; prefrontals 3 or more *Pituophis melanoleucus sayi*
Scale rows less than 27; prefrontals 2 32
32. Infralabials 8 or more on each side of head 33
Infralabials less than 8 on each side of head 37
33. Lateral stripe involving fourth scale row; parietal light spots usually present. 34
Lateral stripe not touching fourth scale row; no parietal spots. 36
34. Supralabial sutures margined with black; tail length less than 27 per cent of total length *Thamnophis radix radix*
Supralabials uniform greenish white or yellow; tail length 27 per cent or more of total length. 35
35. Groundcolor black, with orange middorsal and greenish white lateral stripes; supralabials usually 8 on each side
..... *Thamnophis sauritus proximus*
Groundcolor dark brown, with orange or yellow middorsal and yellow lateral stripes; supralabials usually 7 on each side
..... *Thamnophis sauritus sauritus* × *proximus*
36. Lateral stripes regularly interrupted on anterior third or fourth of body by black crossbars
..... *Thamnophis sirtalis semifasciata*
Lateral stripes uninterrupted by black crossbars. *Thamnophis sirtalis sirtalis*
37. Dorsum and venter unmarked.
..... *Virginia* spp. (couplet 16)
Dorsum with longitudinal light stripes; venter with a pair of longitudinal dark stripes or double row of spots.
..... *Tropidoclonion lineatum lineatum*
38. Anal plate divided, fig. 164 44
Anal plate entire, fig. 165 39
39. Dorsal pattern of distinct dark blotches on light groundcolor 41
Dorsal pattern of white dots on black groundcolor 40
40. Yellow spots on almost all dorsal scales
..... *Lampropeltis getulus holbrooki*
Yellow spots few, tending to form rings around body
..... *Lampropeltis getulus niger*
41. Venter unmarked; rostral plate with wartlike protuberance
..... *Cemophora dolia*
Venter with dim gray spots on greenish yellow groundcolor or with prominent black squares on a white groundcolor; rostral scale without protuberance. 42
42. Ventral spots gray and indistinct against the greenish yellow background; borders of dorsal blotches narrower than half a scale length
..... *Lampropeltis calligaster calligaster*
- Ventral spots black, in sharp contrast to the white groundcolor; dorsal blotches with black margins, each margin almost as wide as the length of one scale. 43
43. Dorsal blotches red, extending down sides to first or second scale rows, fewer than 35. *Lampropeltis triangulum syspila*
Dorsal blotches brown, extending down sides to fourth or fifth scale rows, more than 35.
..... *Lampropeltis triangulum triangulum*
44. Scale rows 19 or more; venter black, marked with transverse red bands
..... *Farancia abacura reinwardti*
Scale rows fewer than 19; venter not black or marked with red bands 45
45. Neck with a yellow ring just behind head 46
Neck without yellow ring behind head 48
46. Chin without black spots; venter immaculate or with an interrupted median row of black spots
..... *Diadophis punctatus edwardsi*
Chin with black spots; venter with scattered black spots or a continuous median row of black spots. 47
47. Venter with a median row of spots, often fused and forming a median stripe; usually 15 scale rows
..... *Diadophis punctatus stictogenys*
Venter with scattered black spots or several rows of spots; usually 17 scale rows *Diadophis punctatus arnyi*
48. Loreal present, fig. 168. 49
Loreal absent
..... *Tantilla gracilis hallowelli*
49. Preoculars 1 or more on each side of head 52
Preoculars none 50
50. Scale rows 13 51
Scale rows more than 13
..... *Virginia valeriae elegans*
51. Dorsal color black; ventral color salmon, extending onto third scale row
..... *Carphophis amoenus vermis*
Dorsal color brown; ventral color salmon or pink, extending onto first or second scale rows *Carphophis amoenus helenae*
52. Anterior temporals 1 on each side of head; color green above
..... *Ophedrys vernalis blanchardi*
Anterior temporals 2 or 3 on each side of head; color never green 53
53. Scale rows at posterior end of body 13 or fewer. *Masticophis flagellum flagellum*
Scale rows at posterior end of body 15. 54
54. Back with 50 to 80 blotches, becoming obscured posteriorly
..... juvenile *Coluber constrictor*
Back unmarked, blue-green or blue-black 55
55. Caudals averaging less than 90; venter and chin pale yellow or light gray; dorsum dark blue or blue-green
..... *Coluber constrictor flaviventris*
Caudals averaging 90 or more; venter slate gray, chin white; dorsum blue-black
..... *Coluber constrictor priapus* × *flaviventris*

COLUBRIDAE

Thirty-eight genera of this large, widespread family occur within the United States and Canada. Seventeen genera are represented in Illinois.

Carphophis Gervais

This genus consists of a single species, which occurs only in eastern North America.

Carphophis amoenus (Say)

Three subspecies of worm snakes are recognized, two of which are found in Illinois.

Carphophis amoenus helenae (Kennicott)
Midwest Worm Snake

Celuta helenae Kennicott 1859:100 (type locality: Monticello, Mississippi).

Carphophiops helenae, Cope 1875:34.

Carphophis helenae, S. Garman 1883:101, 166.

Carphophis amoena helenae, Bocourt 1883:536.

Carphophis amoenus helenae, Perkins 1949:27.

Celuta amoena, Kennicott 1855:592.

Carphophiops amaenus, Surface 1906:134.

Carphophiops amoenus, Cope 1875:34.

Carphophis amoenus amoenus nec Say, H. Garman 1892:309-10.

Carphophis amoenus, Boulenger 1894:325.

Carphophiops amoenus amoenus nec Say, Cope 1900:736.

Carphophis amoena, S. Garman 1883:167.

Carphophis amoena amoena nec Say, Jordan 1929:235.

Carphophiops vermis nec Kennicott, Cope 1877:64.

Carphophis amoenus vermis nec Kennicott, H. Garman 1892:309-10.

Carphoris vermis nec Kennicott, Hurter 1893:255.

Diagnosis.—A small burrowing snake (largest Illinois specimen 309 mm. in total length), fig. 174, with smooth scales in 13 rows; ventrals 118 to 129 in males, 127 to 137 in females; caudals 32 to 40 in males, 24 to 27 in females; supralabials 5 + 5; infralabials 6 + 6; postoculars 1 + 1; a minute, sharp spur on the tip of the tail; dorsum brown; venter pink, the ventral color extending dorsad onto the lowermost one-half to $1\frac{1}{2}$ scale rows; internasals and prefrontals fused into large plates (in 89 per cent, Blanchard 1924a); no preoculars.

Variation.—In 26 specimens from which data were taken, the males possess 118 to 129 ventrals (average 121.8), 32 to 40 caudals (average 38.3); the tail comprises 16.9 to 19.9 per cent of the total length. Females have 127 to 137 ventrals (average 132), 24 to 27 caudals (average 26); the tail comprises 10.7 to 14.8 per cent of the total length.

Juveniles usually are more sharply bicolored than adults because of their darker brown or black dorsal color.

No geographic and surprisingly little individual variation in scutellation are evident in the 26 specimens studied in detail. Mean ventral and caudal numbers for samples from the Mississippi Border and Shawnee Hills differ by only 1 scale, despite the



Fig. 174.—An adult *Carphophis amoenus helenae* from Union County, Illinois. The color above is brown or black; below, pale pink to salmon color.

proximity of a *Carphophis amoenus vermis* population that has higher counts.

All 26 specimens agree in the possession of 13 scale rows, 5 + 5 supralabials, fused prefrontal and internasals, and the absence of a preocular. The infralabial formula of 5 + 6 and the postocular formula of 1 + 2 are each represented by single specimens, the remaining 25 snakes displaying formulae of 6 + 6 and 1 + 1, respectively.

In the Midwest worm snake, color and pattern are more variable than lepidosis. In the Lower Mississippi Border sample, the pattern appears somewhat more sharply bicolored than in the Shawnee Hills sample, but the difference may be due to the greater number of juveniles in the specimens available from the Mississippi River bluffs. The encroachment of the ventral color onto the lowermost scale rows is not correlated with geographical distribution. In samples of 13 specimens from the Lower Mississippi Border and 13 from the Shawnee Hills, the same range of individual variation is exhibited. The ventral color extends onto half of the lowermost scale row on some specimens and onto the lower $\frac{1}{4}$ in others, averaging 1.15 scales in each sample.

Habits.—The Midwest worm snake is fossorial. In early spring it is found under rocks, logs, or the bark of stumps. As the ground becomes dry in summer, the worm snake seeks moist situations. This snake appears temporarily dazed when first uncovered, but in a few seconds it becomes active, seeking to burrow into the soil. The writhing, hard, slick body is difficult to pick up, and even when captured this snake has a way of slipping between the collector's fingers. It usually endeavors to press the tiny spur on the tip of its tail into the restraining hand. The worm snake is known to feed on earthworms; it may possibly feed on soft-bodied arthropods also.

Females collected in late spring contain two to four elongate, proportionately very large eggs. The eggs are probably deposited in hollows under large rocks or within hollow logs.

Illinois Distribution.—The Midwest worm snake occurs in abundance along the Mississippi River bluffs from Pike County southward and throughout the Shawnee Hills. Also it is known from scattered localities in eastern Illinois, almost invariably in the vicinity of rock outcrops, fig. 175.



Fig. 175.—Distribution of *Carphophis amoenus*. Vertical hatching indicates the presumed range of the subspecies *helenae*; horizontal hatching, the presumed range of the subspecies *vermis*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Murphysboro (Ditmars 1945); ST. CLAIR COUNTY: (Hurter 1893); WABASH COUNTY: Mount Carmel (Cope 1877).

Carphophis amoenus vermis (Kennicott) Western Worm Snake

Celuta vermis Kennicott 1859:99 (type locality: Missouri).

Carphophis amoena vermis, Langebartel 1947: 27–8.

Diagnosis.—A subspecies of *Carphophis amoenus* (largest Illinois specimen 285 mm.

in total length) differing from *C. a. helenae*, by the more sharply contrasting purplish black dorsal color and the salmon-pink ventral color, the latter color extending dorsad onto the lowermost $1\frac{1}{2}$ to 3 scale rows; the usual presence of internasals; and the higher ventral and caudal counts.

Variation.—Three specimens of the western worm snake are known from Illinois: a female with 140 ventrals, 24 caudals, ventral color extending onto $2\frac{1}{2}$ lower scale rows, and a tail length of 11.9 per cent of the total length; and two males with 135 and 127 ventrals, 38 and 39 caudals, ventral color extending onto the lower $1\frac{3}{4}$ and $2\frac{1}{2}$ scale rows, and tail lengths 12.1 and 17.0 per cent of the total lengths. All three specimens are purplish black above and bright pink beneath. All possess internasals. Other counts are the same as in *helenae*.

Of the three Illinois specimens, the male from Calhoun County approaches *helenae* in its low number of ventrals. Otherwise, the two forms appear specifically distinct.

Habits.—The remarks concerning behavior of *C. a. helenae* apply to this subspecies as well. No information on life history is available for the subspecies in Illinois.

Illinois Distribution.—The western worm snake is known in Illinois only from Calhoun, Adams, and Hancock counties, fig. 175, all of which border the Mississippi River. The range of this race in the state is probably limited to these three counties, inasmuch as *C. a. helenae* is known in the adjacent counties to the east and south.

Farancia Gray

One eastern North American species with two subspecies is included in this highly specialized genus. One of the subspecies inhabits Illinois.

Farancia abacura reinwardti (Schlegel) Western Mud Snake

Homalopsis reinwardtii Schlegel 1837:173
(type locality: Louisiana; revised to vicinity of New Orleans by Schmidt 1953).

Farancia abacura reinwardtii, Cagle 1941:20.
Farancia abacura reinwardti, Schmidt 1953:186.

Farancia abacura, Cope 1877:64.

Hydrops abacurus, S. Garman 1883:36.

Diagnosis.—A large aquatic snake (largest Illinois specimen 1,254 mm. in total



Fig. 176.—An adult *Farancia abacura reinwardti* from Jackson County, Illinois. The color above is shiny blue-black; below there are bright red crossbands.

Table 47.—Sexual variation in Illinois *Farancia abacura*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (4)		FEMALES (3)	
	Range	Mean	Range	Mean
Ventrals.....	188–194	191.6	167–171	169.2
Caudals.....	36–37	36.6	46–49	47.0
Light tail bars.....	8–11	9.3	10–12	11.2
Tail length as percentage of total length.....	10.7–11.2	11.0	14.6–16.0	15.2

length), fig. 176, lustrous blue-black above with 56 to 76 bright red transverse bars alternating with black bars beneath; red bars extending up onto lowermost scale rows; eyes degenerate; tail tip ending in a sharp spur; scales smooth, in 19 or 20 rows; ventrals 167 to 194; caudals 36 to 49; supralabials 7 + 7, sometimes 6 on a side; infralabials 8 + 8, sometimes 9 on a side; postoculars usually 2 on a side, sometimes 1 or none.

Variation.—Sexual characters in *Farancia* are remarkably abundant. The male differs from the female in having a large, bulbar tail, conspicuous suranal zone of reduced scales, and keels on the suranal scales. Other sexual variation is summarized in table 47.

According to H. Smith (1938), the juveniles are like the adults in details of color and pattern.

Nonsexual variation illustrated by seven specimens is as follows: size range 762 to 1,254 mm.; scale rows 20–20–19 in one, 20–19–19 in three, and 19 in three specimens; supralabials 7 + 7 in five, 6 + 7 in two; infralabials 8 + 8 in three, 9 + 9 in four specimens; postoculars 1 + 0 in one, 1 + 1 in one, 1 + 2 in two, and 2 + 2 in three specimens; light, transverse body bars 48 to 64 (average 57); separation medially of neck bars 9 scale rows in one, 10 in one, and 11 in five specimens.

Habits.—Shallow ponds and sloughs with many partially decayed and water-soaked logs provide ideal habitat for the western mud snake. Most of the Illinois specimens, however, have been found crossing roads on rainy nights. Although this species is known locally as the “stinging snake,” most residents of southern Illinois do not seem to realize that this is the reptile presumably responsible for the “hoop snake” fable. A captured individual presses the sharp, horn-



Fig. 177.—Distribution of *Farancia abacura*. Hatching indicates the presumed range of the subspecies *reinwardti* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

like scale on the tip of the tail into the collector’s hand; this defensive mechanism is more startling than painful. Cagle (1942a) reported that a captive ate *Siren*. The species is known to feed on tadpoles and *Amphiuma*.

Cagle (1942a) had a captive female that coiled about her 22 eggs laid on wet wood

rot in early July. The irregular, flexible eggs, which averaged 34.5×19.9 mm., hatched in mid-August, after an incubation period of 41 days.

Illinois Distribution.—This southern species is characteristic of the swamps of the Austroriparian division, fig. 177. It is found in vegetation-choked ponds and flood-plain swamps in the Shawnee Hills area, also. The occurrence of this snake in the Wabash River valley near Mount Carmel has not been substantiated with recent collections, and *Farancia* may have been exterminated in that part of the state.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: PERRY COUNTY: (Cagle 1942a); WABASH COUNTY: Mount Carmel (Cope 1877).

Diadophis Baird & Girard

Three species, each with several subspecies, of this North American genus are known.

Diadophis punctatus (Linnaeus)

Five subspecies of the eastern ringneck snake are recognized; three meet and intergrade with one another in Illinois. All are similar above, fig. 178.

Diadophis punctatus arnyi Kennicott Prairie Ringneck Snake

Diadophis arnyi Kennicott 1859:99 (type locality: Hyatt, Anderson County, Kansas); Cope 1875:38.

Diadophis punctatus arnyi, S. Garman 1883:158.

Diadophis regalis arnyi, Cope 1900:746.

Diadophis punctatus arnyi $\times$ *stictogenys*, Minton & Minton 1948:382.

Diadophis punctatus nec Linnaeus, Stejneger & Barbour 1917:76.

Diadophis regalis nec Baird & Girard, Ditmars 1922:272.

Diagnosis.—A relatively small burrowing snake (largest Illinois specimen 370 mm. in total length), with 15 to 17 rows of smooth scales at mid-body; dorsum slate, blue-black, or brownish black; venter yellow.



Fig. 178.—An adult *Diadophis punctatus edwardsi* from Effingham County, Illinois. In all Illinois subspecies of *D. punctatus*, the color above ranges from slate gray to blue-black; below the color is yellow or orange-yellow. The ring around the neck is yellow.

low or orange-yellow; a distinct, narrow yellow ring across the neck above; chin dark spotted; venter with scattered dark spots or transverse dark markings; ventrals 149 to 160 in males, 165 to 173 in females; ventrals minus caudals 100 to 110 in males, 121 to 132 in females; supralabials usually 7 + 7.

Variation.—In *Diadophis punctatus arnyi*, the male differs from the female in having a higher caudal count, lower ventral count, and smaller difference between ventrals and caudals, table 48. Many males (38

per cent in Illinois) have keels on the scales just above the anus. Juveniles tend to be darker above than adults.

Single individuals from Carroll and Rock Island counties and a sample of nine specimens from Hancock County are assignable to *arnyi*. These specimens are at variance with more western specimens in the heavy black spots on the chin and venter, but the increased amount of black in no way suggests intergradation with eastern subspecies.

The major geographic variation in this subspecies is summarized in table 48.

Table 48.—Geographic variation in Illinois *Diadophis punctatus arnyi* and *D. p. arnyi* × *edwardsi* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	HANCOCK COUNTY (4 MALES, 5 FEMALES)		ADAMS COUNTY (13 MALES, 14 FEMALES)		MONROE-RANDOLPH COUNTIES (11 MALES, 11 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	149-160	154.8	143-154	148.0	147-159	151.2
Female.....	165-173	170.0	150-159	156.6	147-165	160.0
Caudals						
Male.....	46-58	50.2	41-52	49.0	40-51	46.2
Female.....	40-44	42.2	37-46	41.5	39-48	43.1
Ventrals minus caudals						
Male.....	100-110	104.6	94-113	102.1	98-113	104.9
Female.....	121-132	127.7	110-121	115.1	100-122	115.2
Tail length as percentage of total length						
Male.....	20.6-21.7	21.1	17.3-21.9	20.6	17.3-27.5	20.1
Female.....	16.2-17.3	16.6	14.5-19.5	16.7	15.8-19.8	17.1
Total length (mm.).....	166-370	.....	117-361	.....	109-320	.....
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Chin spotted.....	100.0		81.5		95.5	
7 + 7 supralabials.....	100.0		55.5		91.0	
15 scale rows at mid-body.....	22.2		96.5		13.6	
Venter plain or with median row of spots.....	11.0		55.5		9.0	

Individual variation, which shows no geographic correlation, for 58 specimens of *arnyi* and *arnyi* $\times$ *edwardsi* intergrades is as follows: infralabials 8 + 8 in 76 per cent, 7 + 8 in 7 per cent, 7 + 7 in 14 per cent, and 8 + 9 in 3 per cent; preoculars 2 + 2 in 98 per cent, 1 + 1 in 2 per cent; postoculars 2 + 2 in 92 per cent, 2 + 1 in 5 per cent, 1 + 1 in 1.5 per cent, and 2 + 3 in 1.5 per cent. In the 39 specimens with *arnyi*-type ventral patterns, 82 per cent are irregularly spotted, 18 per cent have transverse bars.

Habits.—The prairie ringneck snake is abundant under flat rocks on hill prairies and wooded bluffs during the spring and fall. In midsummer it seeks moist situations and

can sometimes be taken in numbers concentrated in the vicinity of springs or in talus piles bordering low ground. Occasionally several snakes can be found under a single rock. When first uncovered they are temporarily dazed, but in a few seconds they scatter, often before they can be grabbed. Captured individuals do not bite but they excrete a foul-smelling substance. Many individuals curl their tails in corkscrew fashion, displaying the bright red color of the underside. The ringneck snake feeds on salamanders, arthropods, and earthworms. Other small snakes have been reported as food items.

The eggs of the western ringneck snake have not been found in Illinois.

Illinois Distribution.—*D. p. arnyi* is restricted in Illinois to the Mississippi River bluffs from Jo Daviess County to Adams County, fig. 179. Intergrade populations of *edwardsi* $\times$ *arnyi* are known from Adams to Jackson counties along the Mississippi River. The influence of *arnyi* is exhibited only in the populations inhabiting the Mississippi River bluffs proper. A few miles east of these bluffs, even in the same county, no evidence of intergradation can be discerned.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: HANCOCK COUNTY: Warsaw (H. Garman 1892).

Diadophis punctatus edwardsi (Merrem) Northern Ringneck Snake

Coluber edwardsii Merrem 1820:136 (type locality: Pennsylvania; revised to vicinity of Philadelphia by Schmidt 1953).

Diadophis punctatus edwardsii, Van Cleave 1928:133, 136.

Diadophis punctatus punctatus nec Linnaeus, Davis & Rice 1883a:29.

Diadophis punctatus, Cope 1900:753.

Diadophis punctatus amabilis nec Baird & Girard, Davis & Rice 1883a:29.

Diadophis punctatus arnyi nec Kennicott, Schmidt & Necker 1935:61.

Diadophis punctatus strictogenys nec Cope, Cagle 1942a:186.

Diagnosis.—A subspecies of *Diadophis punctatus* (largest Illinois specimen 346 mm. in total length), fig. 178, differing from *D. p. arnyi* in the usual presence of 15 scale rows at mid-body; chin usually without dark



Fig. 179.—Distribution of *Diadophis punctatus*. Vertical hatching indicates the presumed range of the subspecies *edwardsi* in Illinois; horizontal hatching, the presumed range of the subspecies *arnyi*; diagonal hatching, the presumed range of the subspecies *stictogenys*; crosshatching, the areas of intergradation between subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

spots; venter immaculate or with a median row of round dark spots; ventrals 138 to 147 in males, 151 to 160 in females; ventrals minus caudals 85 to 98 in males, 102 to 114 in females; supralabials usually 8 + 8; underside of tail yellow.

Variation.—Sexual and ontogenetic variation in this subspecies parallel that shown by *D. p. arnyi*. Suranal keels are present on 43 per cent of the Illinois males available.

Geographic variation in *D. p. edwardsi* is summarized in table 49.

Individual, nongeographic variation is as follows: infralabials 8 + 8 in 41.7 per cent

of specimens, 7 + 8 in 29.1 per cent, 7 + 7 in 8.3 per cent, 6 + 7 in 4.2 per cent, 6 + 6 in 8.3 per cent, 8 + 9 in 4.2 per cent, and 9 + 9 in 4.2 per cent; preoculars 2 + 2 in 95.8 per cent, 1 + 1 in 4.2 per cent; postoculars 2 + 2 in 87.5 per cent, 1 + 2 in 8.3 per cent, 1 + 1 in 4.2 per cent. In 23 specimens with typical *edwardsi* ventral pattern, 50 per cent possess a median row of dark spots; 50 per cent are plain yellow.

Habits.—Behavior characteristics and feeding habits of this race are apparently much the same as those of *D. p. arnyi*.

Fourteen elongate eggs of *D. p. edwardsi*

Table 49.—Geographic variation in Illinois *Diadophis punctatus edwardsi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	WABASH BORDER (7 Males, 6 FEMALES)		SHAWNEE HILLS (4 MALES, 5 FEMALES)		GREENE-PIKE COUNTIES (5 MALES, 4 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	138-146	142.8	143-147	144.7	139-150	144.6
Female.....	140-157	149.4	151-160	154.6	147-158	152.5
Caudals						
Male.....	47-56	50.8	47-51	49.0	47-50	48.7
Female.....	43-54	48.8	46-49	47.6	38-45	41.5
Ventrals minus caudals						
Male.....	85-97	92.0	92-98	95.7	90-101	96.0
Female.....	89-109	100.5	102-114	107.0	107-113	111.0
Tail length as percentage of total length						
Male.....	20.8-23.6	22.2	19.5-22.0	20.6	20.2-22.0	20.1
Female.....	18.0-22.7	19.6	17.0-21.1	18.8	15.8-17.8	16.7
Total length (mm.).....	139-395		118-320		135-306	
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Chin spotted.....	31.0		43.0		33.3	
7 + 7 supralabials.....	37.5		71.5		55.5	
15 scale rows at mid-body.....	100.0		100.0		100.0	
Venter plain or with median row of spots	100.0		100.0		100.0	

were found under a flat rock on a floodplain in late June. These eggs, which averaged 23.6×9.5 mm., hatched August 18. It is possible that the 14 eggs were laid by more than one female.

Illinois Distribution.—The present range in Illinois, fig. 179, of the northern ringneck snake is of considerable interest. Scattered colonies exist in the Wabash Border counties, across the Shawnee Hills, and along the lower Illinois River bluffs at least in Pike and Greene counties. Most of the interior of Illinois between the Illinois and the Wabash rivers lacks the requisite rock outcrops and appears to be uninhabited by *Diadophis*. The lower Illinois River bluff population, which is evidently pure *edwardsi*, is thus an eastern remnant that is isolated from other *edwardsi* populations by uninhabitable terrain, as are also the intergrade populations of *arnyi* $\times$ *edwardsi*.

Blanchard (1942) cites two specimens from Havana, Mason County, Illinois. These specimens cannot be located, but in view of the disjunct range of the race, *edwardsi* is the subspecies to be expected in Mason County.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Murphysboro (Cagle 1942a); MASON COUNTY: Havana (Blanchard 1942); WABASH COUNTY: Mount Carmel (Cope 1900).

***Diadophis punctatus stictogenys* Cope**
Mississippi Ringneck Snake

Diadophis punctatus stictogenys Cope 1860a: 250 (type locality: unknown; designated as southern Illinois by Schmidt 1953); H. Garman 1892:302.

Diadophis punctatus arnyi $\times$ *stictogenys*, Minton & Minton, 1948:382.

Diadophis punctatus stictogenys, Van Cleave 1928:133, 136.

?*Diadophis punctatus arnyi* nec Kennicott, Blanchard 1942:69-87 (part).

Diagnosis.—A southern subspecies of *Diadophis punctatus* (largest Illinois specimen 225 mm. in total length), differing from *D. p. arnyi* and *D. p. edwardsi* in the following combination of characters: scale rows at mid-body usually 15; chin spotted with dark; venter with median row of spots, with transverse markings, or irregularly

spotted; ventrals 126 to 157 in males, 137 to 161 in females; ventrals minus caudals 79 to 111 in males, 98 to 119 in females; supralabials usually 7 + 7.

Variation.—In sexual and ontogenetic variation *stictogenys* presumably does not differ from the other subspecies of *D. punctatus*.

Individual variation for six males and five females is as follows: size range 146 to 267 mm.; ventrals in males 140 to 157 (average 147.3), in females 147 to 161 (average 156.2); caudals in males 45 to 49 (average 47.0), in females 40 to 49 (average 44.4); ventrals minus caudals in males 94 to 111 (average 100.3), in females 98 to 118 (average 111.8); tail length in males 19.3 to 22.8 (average 20.5) per cent of total length; in females 15.7 to 20.9 (average 17.8) per cent; supralabials 7 + 7 in 91 per cent of specimens, 8 + 8 in 9 per cent; infralabials 7 + 7 in 18 per cent, 8 + 8 in 82 per cent; preoculars 2 + 2 in 82 per cent, 1 + 2 in 9 per cent, 1 + 1 in 9 per cent; chin spotted in 91 per cent, plain in 9 per cent; venter with median row of spots in 54 per cent, with scattered spots in 9 per cent, intermediate in 28 per cent, and with transverse markings in 9 per cent; scale rows at mid-body 15 in 91 per cent, 17 in 9 per cent.

The Illinois specimens are typical *stictogenys*, except for their high ventral counts (an average of 10 to 15 more ventrals than in the South). The high counts may result from genic exchange with adjacent populations of *edwardsi*, or they may reflect a south-to-north clinal increase in numbers of ventrals in *stictogenys*.

Habits.—Behavior characteristics, habitat, and feeding habits of the Mississippi ringneck snake are similar to those of the other Illinois subspecies of *D. punctatus*. No life history information is available for *stictogenys*, but this race is probably similar to the other races in this respect.

Illinois Distribution.—The Mississippi ringneck snake is known only from bluffs bordering the Mississippi and Ohio river lowlands in Union, Alexander, and Johnson counties, fig. 179. It may occur also in Pulaski and Massac counties.

Heterodon Latreille

Three species, one with several subspecies, of this North American genus occur in

the United States and Canada. Two species are known in Illinois.

Heterodon nasicus Baird & Girard

Three subspecies of the western hognose snake have been described. *Heterodon nasicus* is known in Illinois only from a few scattered relict colonies. The northern relicts are referable to the nominate race; the southern colonies appear to represent an intergrade population of *H. n. nasicus* × *gloydi*. However, additional specimens from Morgan and Cass counties may reveal that the population in these counties invariably has few blotches and is actually typical *H. n. gloydi* rather than an intergrade population.

Heterodon nasicus nasicus
Baird & Girard
Plains Hognose Snake

Heterodon nasicus Baird & Girard 1852:352-3 (type locality: Texas; revised to Amarillo by Schmidt 1953); Vestal 1913:61, 75, 87.
Heterodon simus nasicus, H. Garman 1892: 304-5.
Heterodon nasicus nasicus, Cagle 1941:15.

Diagnosis.—A medium-sized, stout-bodied snake (largest Illinois specimen 593 mm. in total length), fig. 180, with an enlarged, shovel-like rostral plate; rostral sharply upturned as seen in lateral profile; belly and underside of tail predominantly black; scales keeled, usually in 23-23-19 rows; ventrals 130 to 148; caudals 29 to 47; numerous azygous scales on top of snout; 27 to 42 brown dorsal blotches on a grayish tan groundcolor.

Variation.—Sexual dimorphism in this snake, tables 50 and 51, is exhibited in the size of the tail, and number of ventrals, caudals, body blotches, and tail rings.

Very young specimens are proportionately larger headed and are more prominently blotched than adults.

Two samples of this snake are available, one from the scattered sand prairies along the Mississippi River and one from the Illinois River sand area. The latter sample, from Morgan to Tazewell counties and the area between, is tentatively regarded as representing an intergrade population, inasmuch as the average dorsal blotch count is intermediate between that of *Heterodon*



Fig. 180.—An adult *Heterodon nasicus nasicus* from Henderson County, Illinois. The groundcolor is tan, gray, or light brown; the dorsal markings are dark brown; the ventral markings, black.

Table 50.—Sexual variation in Illinois *Heterodon nasicus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (11)		FEMALES (7)	
	Range	Mean	Range	Mean
Tail length as percentage of total length.....	12.0-19.1	16.8	9.7-13.6	12.1
Ventrals.....	130-136	132.3	134-148	142.0
Caudals.....	32-47	41.3	29-36	33.7

Table 51.—Geographic variation in Illinois *Heterodon nasicus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MORGAN-TAZEVELL COUNTIES (7 MALES, 3 FEMALES)		NORTHWESTERN ILLINOIS (3 MALES, 5 FEMALES)	
	Range	Mean	Range	Mean
Ventrals				
Male.....	131-134	132.5	130-136	132.0
Female.....	134-142	139.3	141-148	144.0
Caudals				
Male.....	34-44	40.8	32-45	40.5
Female.....	34-36	35.0	29-36	32.5
Tail length as percentage of total length				
Male.....	16.1-19.1	17.9	12.0-17.4	15.3
Female.....	12.8-13.4	13.1	9.7-13.6	11.9
Body blotches				
Male.....	27-34	32.0	34-41	36.2
Female.....	34-42	38.0	35-41	38.5
Tail rings				
Male.....	12-15	13.1	12-14	13.2
Female.....	11-12	11.3	9-14	11.0
Scales associated with azygous scale.....	11-15	13.1	13-20	15.8

nasicus nasicus and *H. n. gloydi*. A reduction in the number of scales is also suggested, although the significance of this trend is unknown, since lepidosis is presumably the same for both races. Variation in blotch counts and scutellation for two samples is summarized in table 51.

The numbers of scale rows and labials show no geographic correlation. Scale rows behind the head are usually 23, occasionally 22, 24, or 25; at mid-body usually 23, occasionally 21 or 22; preceding the anus usually 19, occasionally 18. Supralabials are 8 + 8 in 17 specimens, 8 + 9 in 1; infra-labials are usually 11 + 11, occasionally 10 on one or both sides.

Habits.—The plains or western hognose snake is slow moving; apparently it spends much of its time searching the sand prairies

and adjacent wood lots for toads. In open sand areas, the hognose snake leaves unmistakable signs. The tracks of a snake are unusually wide because of the stout body, and at intervals small craters are found where the snake has dug up resting toads. Unlike most snakes, the hognose snake is seldom found beneath objects. It apparently utilizes mammal holes and remains underground during cold or wet weather. The snake displays a bluffing attitude when first approached. It spreads its head and neck and it hisses loudly. If this bluff fails, the snake feigns death by rolling over on its back. If it is turned right side up it will promptly roll over on its back again. Newly captured individuals usually do not bite.

H. nasicus feeds on toads, frogs, other snakes, birds, and mice. It is oviparous.



Fig. 181.—Distribution of *Heterodon nasicus*. Vertical hatching indicates the presumed range of the subspecies *nasicus*; crosshatching, the area of intergradation between the subspecies *nasicus* and *gloydi*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States. The southeastern Missouri colony is *gloydi*.

Illinois Distribution.—It is virtually certain that in Illinois the western hognose snake is restricted to the sand areas, fig. 181. Its range is thus a series of small, scattered relicts of a formerly widespread occurrence. Most specimens have been found crossing sandy roads or in brushy or weedy sites in the sand prairies, where *nasicus* is at least as common as the more widespread *H. platyrhinos*.

The Illinois populations are of some zoogeographic interest inasmuch as the small samples available indicate that relict colonies of pure *nasicus* and a relict population of *nasicus* $\times$ *gloydi* persist. The differentiation of these subspecies thus appears to antedate the postglacial Xerothermic Period.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: MASON COUNTY: SE Havana (Vestal 1913); TAZEWELL COUNTY: Pekin (H. Garman 1892).

Heterodon platyrhinos Latreille Eastern Hognose Snake

Heterodon platyrhinos Latreille 1801:432 (type locality: designated vicinity of Philadelphia, Pennsylvania, by Schmidt 1953); Kennicott 1855:592.

Heterodon platyrhinos platyrhinos, A. Smith 1951:4.

Heterodon platyrhinos platyrhinos, Yarrow 1882a:138–9.

Heterodon platyrhinos, Cope 1900:768, 769.

Heterodon platyrhinos, Hay 1891:114.

Heterodon platyrhinos niger, H. Garman 1892:302–4.

Heterodon contortrix, Frison & Miller 1926:471.

Heterodon contortrix contortrix, Pope 1944b:165–8.

Heterodoa platyrhinos, Adcock 1922:196.

Diagnosis.—A medium-sized, stout-bodied snake (largest Illinois specimen 913 mm. in total length), fig. 182, with an enlarged, shovel-like rostral plate; rostral, as seen in lateral profile, not turned up; belly light or dark, underside of tail always light; usually 25–25–19 rows of keeled scales around the body; ventrals 122 to 147; caudals 38 to 57; 1 or 2 unpaired scales on snout behind the rostral plate; 19 to 29 dark body blotches on a gray, tan, or brownish groundcolor, or dorsal surface olive, brown, or black and without spots.

Variation.—In this species, the male differs from the female in the relative tail length and in the number of ventrals, caudals, body blotches, and tail rings. Sexual variation for 32 males and 22 females is summarized in table 52.

Young specimens are proportionately larger headed and more prominently blotched than adults. In the young, the venter, except the neck and the under part of the tail, is black. Older specimens may retain the juvenile dorsal pattern, but in adults the venter is light. The dorsal pattern of adults is extremely variable; some specimens are distinctly blotched, some are melanistic, and others are intermediate in varying degrees. Occasional specimens are brick-red, with black blotches.



Fig. 182.—An adult *Heterodon platyrhinos* from Lee County, Illinois. The groundcolor may be tan, gray, rusty red; the markings, dark gray, brown, or black. Frequent specimens are unicolor olive or black; others, dark with vestiges of the blotched pattern.

Table 52.—Sexual variation in Illinois *Heterodon platyrhinos*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (32)		FEMALES (22)	
	Range	Mean	Range	Mean
Ventrals.....	122-134	128.2	134-147	141.6
Caudals.....	44-57	48.7	38-48	42.6
Body blotches.....	19-29	22.6	21-29	24.9
Tail rings.....	7-11	8.9	6-10	7.9
Tail length as percentage of total length.....	15.7-20.8	17.9	12.7-16.6	14.4

No geographic variation in scutellation in Illinois *Heterodon platyrhinos* has been discerned. Of 54 specimens examined, 3.7 per cent have 24 anterior rows of scales, 67 per cent have 25, 18 per cent have 26, and 11 per cent have 27; 6 per cent have 23 scale rows at mid-body, 4 per cent have 24, 83 per cent have 25, 5 per cent have 26, and 2 per cent have 27; 6 per cent have 18 posterior scale rows, 85 per cent have 19, 2 per cent have 20, and 7 per cent have 21. Supralabials are 7 + 8 in 7 per cent, 8 + 8 in 87 per cent, and 8 + 9 in 6 per cent. Infra-labials are 8 + 9 in 2 per cent, 9 + 9 in 6

per cent, 9 + 10 in 11 per cent, 10 + 10 in 60 per cent, 9 + 11 in 2 per cent, 10 + 11 in 6 per cent, 11 + 11 in 11 per cent, and 11 + 12 in 2 per cent.

Other variation is summarized in table 53. The average number of body blotches tends to be higher in snakes from northern localities than in those from other parts of the state.

Habits.—The eastern hognose snake is similar in habits to *Heterodon nasicus*. When encountered in the field it spreads its head and neck widely and hisses; if this bluff fails, it rolls over on its back and “plays

Table 53.—Geographic variation in Illinois *Heterodon platyrhinos*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (8 MALES, 8 FEMALES)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (12 MALES, 5 FEMALES)		NORTH- CENTRAL ILLINOIS (7 MALES, 7 FEMALES)		EXTREME NORTHERN ILLINOIS (5 MALES, 2 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals								
Male.....	126-132	129.0	126-134	129.0	123-132	128.2	122-134	126.6
Female.....	140-147	145.8	134-146	141.8	136-143	138.5	138-143	140.5
Caudals								
Male.....	44-53	48.8	48-57	50.7	44-53	48.2	44-52	47.2
Female.....	40-46	43.2	41-44	42.0	38-44	41.0	41-48	44.5
Body blotches								
Male.....	19-25	21.7	20-24	21.8	22-25	22.8	22-29	24.2
Female.....	21-27	25.0	21-25	22.7	21-28	24.0	27-29	28.0
Tail rings								
Male.....	8-10	9.2	7-10	8.0	8-10	9.4	8-11	9.0
Female.....	7-9	8.1	7-8	7.2	6-9	7.5	8-10	9.0
Tail length as per- centage of total length								
Male.....	16.4-20.8	18.2	18.6-20.3	19.4	16.3-20.1	18.1	15.7-20.4	18.2
Female.....	12.7-16.2	14.6	13.6-14.3	14.1	12.7-15.2	13.8	14.3-16.6	15.4
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Juvenile pattern....	6		18		14		0	
Melanistic.....	25		23		36		14	
Intermediate pattern	68		59		50		86	

possum." Although this species rarely bites, it is unpleasant to handle because of its copious, ill-smelling excretions. It feeds primarily on toads and to some extent on frogs and treefrogs. Captive specimens have been induced to take crickets and even chunks of raw liver. The hognose, though not especially hardy, is a popular snake pet.

The elongate eggs of this snake are sometimes found under rocks. A captive depos-

ited 15 eggs on June 21; these hatched between August 11 and 17. Another captive laid 17 eggs on August 28, none of which hatched, probably because of captivity-induced delay in oviposition. These eggs averaged 30×18 mm. Cagle (1942a) recorded broods of 4 and 35 eggs; he found the average length to be much less, suggesting that egg size is correlated with the size of the female snake.



Fig. 183.—Distribution of *Heterodon platyrhinos*. The species apparently occurs throughout Illinois, although there are small localized areas where it appears to be absent. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Illinois Distribution.—The eastern hog-nose snake is state-wide in occurrence in Illinois, fig. 183. The snake is evidently rare in much of the central part of the state, especially in areas that were originally muck prairie. Its rarity in these areas may be explained by its apparent avoidance of soil rich in organic matter, or its near extermination from areas intensively cultivated. The species is abundant throughout the southern half of Illinois, particularly on floodplains, in forest-edge habitats, and in dry, open woods where the soil is clay or sandy loam. The hog-nose snake is apparently common in the sand areas of northern Illinois, where the abundance of toads, the principal food of *Heterodon*, is probably an important factor.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: ALEXANDER COUNTY: Horseshoe Lake (Minton & Minton 1948); HANCOCK COUNTY: 7 mi. S Nauvoo (Langebartel 1947); HARDIN COUNTY: Shawnee National Forest (H. Smith 1956); KNOX COUNTY: 2½ mi. E Galesburg (Adcock 1922); MADISON COUNTY: (Hurter 1911); MONROE COUNTY: Waterloo (Burt 1935); PEORIA COUNTY: (H. Garman 1892); ROCK ISLAND COUNTY: Rock Island (Yarrow 1882a); ST. CLAIR COUNTY: Belleville (Yarrow 1882a); TAZEWELL COUNTY: (H. Garman 1892); UNION COUNTY: Saratoga (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882a); WILL COUNTY: Wilmingtong (Schmidt & Necker 1935).

Opheodrys Fitzinger

Two species of this North American and Asiatic genus occur in the United States and Canada. Both are found in Illinois.

Opheodrys aestivus (Linnaeus) Rough Green Snake

Coluber aestivus Linnaeus 1766:387 (type locality: Carolina; revised to Charleston, South Carolina, by Schmidt 1953).

Cyclophis aestivus, Cope 1875:38.

Phyllophilophis aestivus, H. Garman 1892: 283-4.

Phillophilophis aestivus, Hurter 1893:256.

Opheodrys aestivus, Hurter 1911:191.

Diagnosis.—An extremely slender snake (largest Illinois specimen 847 mm. in total length), fig. 184, with 17-15 rows of keeled scales; supralabials usually 7 + 7 and infralabials 8 + 8; preoculars usually 1 + 1 and postoculars 2 + 2; nasal single; ventrals 139 to 171; caudals 116 to 152; tail length 32.7 to 46.4 per cent of total length; body green (blue or black in preservative) above, white or yellowish white below.

Variation.—Because of the great amount of overlap in sexual characters in this species, the greater number of caudals, the longer tails, and the reduced ventral counts of males can be detected only in the averages. Fifteen adult male specimens possess 126 to 140 caudals (average 132.9) and 150 to 164 ventrals (average 154.7); tail length ranges from 36.0 to 45.4 (average 40.0) per



Fig. 184.—An adult *Opheodrys aestivus* from Monroe County, Illinois. The color above is bright green; below, yellowish white.

Table 54.—Geographic variation in Illinois *Opheodrys aestivus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME SOUTHERN ILLINOIS (10 MALES, 11 FEMALES)		SOUTHEASTERN ILLINOIS (13 MALES, 8 FEMALES)		LOWER MISSISSIPPI BORDER (6 MALES, 5 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	150-170	155.7	150-164	154.5	149-161	157.0
Female.....	139-165	156.0	153-171	159.2	154-157	155.6
Caudals						
Male.....	126-152	133.4	122-137	131.3	119-133	124.1
Female.....	116-132	126.1	116-133	123.3	121-128	123.2
Tail length as percentage of total length						
Male.....	35.4-45.4	39.4	36.8-41.3	39.9	36.4-38.2	37.3
Female.....	34.4-40.1	37.1	32.7-41.3	35.5	33.8-37.2	35.8
Total length (mm.).....	198-347	.....	182-836	.....	213-684	.....

cent of total length. Fifteen adult female specimens possess 116 to 133 caudals (average 123.3) and 152 to 171 ventrals (average 159.1); tail length ranges from 32.7 to 40.0 (average 36.5) per cent of total length.

Juveniles are proportionately larger headed, shorter tailed, and (in preservative) more sharply bicolored. For five juvenile females the tail length averages 34.7 per cent of total length, for four juvenile males 36.3 per cent.

Some geographic variation in the degree of sexual dimorphism in the rough green snake is suggested by a comparison of the means of ventral and caudal counts and ratios of tail length to total length for three samples from extreme southern Illinois, southeastern Illinois, and the Lower Mississippi Border. In females a slight reduction in the number of ventrals and caudals and proportionate tail length can be discerned from east to west; in males the trend is considerably more pronounced. This variation and the size ranges are summarized in table 54.

Other variation in scutellation seems to be individual, although the presence of 2 postoculars tends to be more frequent in eastern specimens than in others. Fifty-three specimens show the following variation in head scutellation: supralabials 7 + 7 in 51, 7 + 8 in 1, and 6 + 7 in 1; infralabials 8 + 8 in 47, 7 + 8 in 5, and 6 + 6 in 1; preoculars 1 + 1 in 40, 2 + 2 in 9, and 2 + 1 in 4; postoculars 2 + 2 in 47, 1 + 2 in 2, 1 + 3 in 1, 1 + 1 in 1, and 2 + 3 in 2.

Habits.—The rough green snake is arboreal and is seen most often in bushes and vines. It is most easily found in vegetation overhanging streams or lakes, particularly after summer showers. The green snake is nervous and quick. Newly captured individuals often open their mouths wide, exposing the purple mouth cavity. Despite its threatening behavior this snake does not bite. Its food consists of various soft-bodied arthropods, insects, and spiders.

The species is oviparous. A clutch of six elongate eggs was once found under a flat rock. No other life history information is available for the green snake in Illinois.

Illinois Distribution.—The rough green snake, a forest-edge species, is more common in the southern half of Illinois than is indicated by the available specimens, fig. 185. In central Illinois it is abundant north to

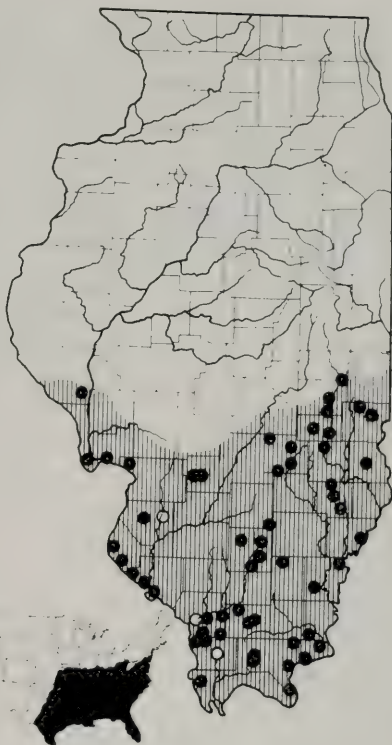


Fig. 185.—Distribution of *Opheodrys aestivus*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the species in the United States.

the Shelbyville Moraine, where its range ceases abruptly. In extreme eastern Illinois and along the Mississippi River, apparently suitable habitat extends considerably farther north than the known range of the species.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: 4 mi. W Murphysboro (Minton & Minton 1948); ST. CLAIR COUNTY: Mascoutah (Hurter 1893); UNION COUNTY: Anna (H. Garman 1892).

Opheodrys vernalis blanchardi Grobman Western Smooth Green Snake

Opheodrys vernalis blanchardi Grobman 1941: 11 (type locality: Spanish Peaks, Colorado); Cagle 1941:22.

Opheodrys vernalis vernalis × *blanchardi*, Grobman 1941:17, 20.

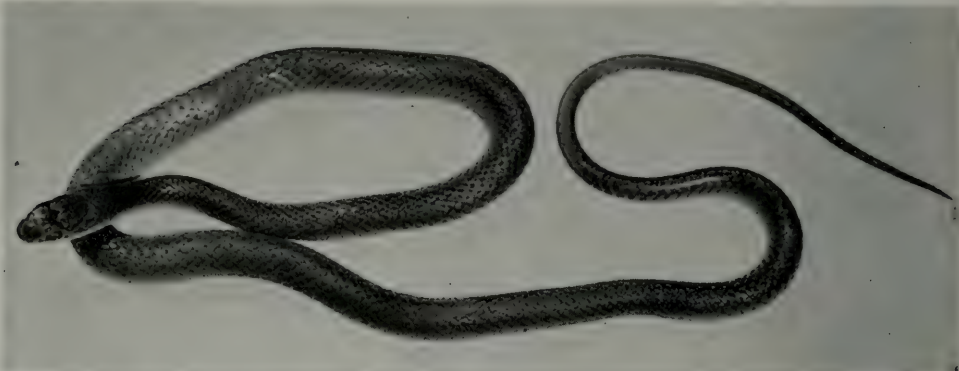


Fig. 186.—An adult *Opheodrys vernalis blanchardi* from Livingston County, Illinois. The color above is bright or dull green; below, white.

Chlorosoma vernalis, Kennicott 1855:592.
Cyclophis vernalis, Davis & Rice 1883a:29.
Contia vernalis, Boulenger 1894:259.
Liopeltis vernalis, Cope 1900:783.
Eurypholis vernalis, Schmidt & Necker 1935: 68.
Entechinus vernalis, Pope 1937:216.
Opheodrys vernalis, Necker 1938:2.

Diagnosis.—A small green snake (largest Illinois specimen 565 mm. in total length), fig. 186, with 15 rows of smooth scales around the body; ventrals 127 to 150; caudals 71 to 91; supralabials 7 + 7; infralabials usually 7 + 7; preoculars 1 or 2, and postoculars 2 on each side.

Variation.—In this subspecies the male has a higher caudal count and a longer tail but fewer ventrals than the female. Twenty-two male specimens have 127 to 140 ventrals (average 132.6) and 79 to 96 caudals (average 87.6); the tail length ranges from 24.5 to 36.5 (average 32.2) per cent of total length. Twenty-seven females have 134 to 150 ventrals (average 145.1) and 71 to 86

caudals (average 78.6); the tail length ranges from 23.7 to 30.9 (average 27.7) per cent of total length.

Newly hatched green snakes are dark olive-green. The slightly older juveniles are gray-green. Necker (1939a) reported buff-colored anomalies in yearling snakes. Young specimens are proportionately larger headed and shorter tailed than adults. The onto-

Table 55.—Ontogenetic variation in proportionate tail length in three size classes of Illinois *Opheodrys vernalis*. Figures in parentheses are numbers of specimens.

TOTAL LENGTH (MM.)	TAIL LENGTH AS PER CENT OF TOTAL LENGTH	
	Male	Female
Under 200.....	30.6 (10)	26.7 (11)
200-400.....	33.1 (7)	28.5 (7)
Over 400.....	34.1 (5)	28.7 (7)

Table 56.—Geographic variation in Illinois *Opheodrys vernalis*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHEASTERN ILLINOIS (13 MALES, 8 FEMALES)		NORTHWESTERN ILLINOIS (1 MALE, 13 FEMALES)		EAST-CENTRAL ILLINOIS (8 MALES, 12 FEMALES)		MARION COUNTY (1 FEMALE)
	Range	Mean	Range	Mean	Range	Mean	
Ventrals							
Male.....	127-135	132.1	130	.....	127-140	133.8	.....
Female.....	139-149	144.0	134-147	142.6	143-150	146.7	149
Caudals							
Male.....	79-89	85.0	91	.....	79-96	91.1	.....
Female.....	72-82	76.0	71-82	77.5	76-86	80.6	79

genetic variation in proportionate tail length is summarized in table 55.

The most notable intrastate variation in *Opheodrys vernalis* is the smaller number of caudals in males from northeastern Illinois than in those from elsewhere in the state. In this regard the northeastern Illinois population approaches the nominate race; it was, in fact, regarded as an intergrade population by Grobman (1941). However, the females from this part of the state have caudal counts more or less typical of *blanchardi*, and the ventral counts of all the Illinois green snakes suggest *blanchardi*. Geographic variation within the state in number of ventrals and caudals is summarized in table 56.

Geographic variation in this species is rather unique. The two subspecies of *O. vernalis* are extremely similar morphologically, differing only in averages of a few characters. The two races, nevertheless, appear to be distinct biological entities, one occupying a grassland habitat in the west and the other inhabiting forest in the east. Moreover, despite their slight differences, they seem to be incipient species; in much of the area presumed to be intergrade in nature, the species is extinct or is known from relatively few scattered relicts. Thus, free interbreeding probably does not occur in a large part of the area where *blanchardi* and the nominate race presumably are in contact. The northeastern Illinois population, which shows some influence of *vernalis*, is actually part of a continuous *blanchardi* population but is separated from the closest continuous population of *vernalis* by a hiatus of probably 200 miles.

Individual variation in other features of scutellation in 49 Illinois specimens are as follows: scale rows 15 throughout in 98 per cent, 13-15-15 in 2 per cent; supralabials 7+7 in 98 per cent, 7+8 in 2 per cent; infralabials 7+7 in 51 per cent, 8+8 in 25 per cent, 7+8 in 14 per cent, 6+7 in 8 per cent, and 7+5 in 2 per cent; preoculars 1+1 in 61 per cent, 1+2 in 22 per cent, 2+2 in 17 per cent; postoculars 2+2 in 98 per cent, 2+1 in 2 per cent.

In addition to buff-colored anomalies, Necker (1939a) reported a single blue example of the western smooth green snake.

Habits.—The western smooth green snake is terrestrial; specimens are occasionally seen in low bushes and in grass. The

most successful collecting method consists of raising pieces of ground cover, such as rocks, boards, paper, and other debris, and grabbing the snakes beneath. This species is a prairie animal. Since destruction of much of the original prairie habitat, scattered colonies have been found mostly in wet meadows and vacant lots in suburban areas. The green snake is rather slow in its movements and does not attempt to bite. Its food consists predominantly of soft-bodied arthropods.

Stille (1954a) records the average clutch size for the Chicago region as about 6, with a range of 5 to 15 eggs. The individual eggs measure about 22×10.5 mm. In the Chicago area, oviposition occurs in mid-July, and a month is required for the eggs to

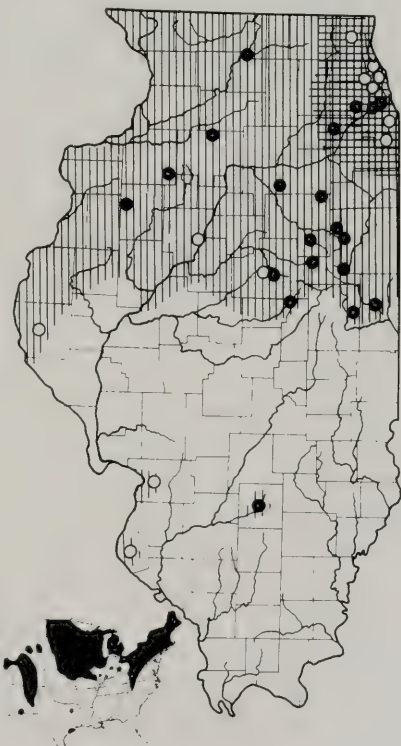


Fig. 187.—Distribution of *Opheodrys vernalis*. Vertical hatching indicates the presumed range of the subspecies *blanchardi* in Illinois; crosshatching, the area of intergradation between the subspecies *blanchardi* and *vernalis*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

hatch. Eighteen eggs, laid by a large female in Champaign County on July 12, hatched on August 10.

Illinois Distribution.—The present distribution of the western smooth green snake, fig. 187, appears to be sporadic. In northern Illinois, colonies are often found in vacant lots, where individuals may be quite abundant. Toward the south, colonies become more widely scattered. Many of them have in all likelihood been exterminated within historic times as more and more prairie areas have been cultivated. There are valid records of the species as far south as Marion, Madison, and Monroe counties, but no specimens have been taken in southern Illinois for many years.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: ADAMS COUNTY: (Grobman 1941); COOK COUNTY: Berwyn, Beverly Hills, Elmwood Park, Evanston, Glencoe (Schmidt & Necker 1935); Harvey (Necker 1939c); Homewood, Morgan Park, Park Ridge, Purington (Schmidt & Necker 1935); LAKE COUNTY: (Schmidt & Necker 1935); MCLEAN COUNTY: Normal (H. Garman 1892); MADISON COUNTY: (Hurter 1903); MONROE COUNTY: (H. Garman 1892); PEORIA COUNTY: Peoria (H. Garman 1892).

Coluber Linnaeus

A single species, with numerous subspecies, of this North American and Asiatic genus occurs in the United States and Canada.

Coluber constrictor Linnaeus

Eight subspecies of this wide-ranging species are currently recognized. Geographic variation in this species within Illinois is pronounced but distinctly clinal. Only one race and an intergrade population can be regarded as occurring in the state, despite the many published reports of both the eastern black racer and the western blue racer. Racers from southern Illinois differ from those in central and northern Illinois in color, caudal counts, and relative tail length. Series from the southern part of the state are not typical of the eastern race *constrictor* or the Gulf Coast race *priapus*, but are more

or less intermediate between the western race *flaviventris* and either *constrictor* or *priapus*. Although they share with *priapus* the enlarged basal hooks on the hemipenes (and thus differ from *constrictor*), their possession of hemipenial hooks can be explained by regarding these snakes as *constrictor* × *flaviventris* intergrades, inasmuch as *flaviventris* also has enlarged hemipenial hooks. Despite two equally plausible interpretations on strictly morphological grounds, the southern Illinois racers are referred to *C. c. flaviventris* × *priapus* rather than to *C. c. constrictor* × *flaviventris* to conform with the distributional relationships outlined by Auffenberg (1955).

The resurrection of *C. c. foxi* Baird & Girard in the recent check list (Schmidt 1953) for the Prairie Peninsula racers is unexplained. In view of the almost identical scutellation of racers from northwestern Ohio, central Illinois, and Nebraska, *C. c. foxi* is almost certainly a junior synonym of *flaviventris*.

Coluber constrictor flaviventris Say Eastern Yellow-Bellied Racer Blue Racer

Coluber flaviventris Say 1823:185 (type locality: stone quarry on west side of Missouri River, 3 miles above Boyer's River, Pottawattamie County, Iowa).

Coluber constrictor flaviventris, Ortenburger 1928:179.

Coluber constrictor constrictor × *flaviventris*, Lueth 1941:29.

Bascanion constrictor, Kennicott 1855:592.

Bascanium constrictor, Yarrow 1882a:109-10.

Bascanion constrictor constrictor nec Linnaeus, Davis & Rice 1883a:30.

Coluber constrictor, H. Garman 1890:187.

Coluber constrictor constrictor nec Linnaeus, Blanchard 1924b:536.

Coluber constrictor foxi, Schmidt 1953:187.

Diagnosis.—A moderately slender, large snake (largest Illinois specimen 1,535 mm. in total length), fig. 188, with 17-17-15 rows of smooth scales; ventrals 168 to 189; caudals 71 to 97; supralabials usually 7 + 7; infralabials 8 + 8; preoculars 2 + 2, the lowermost minute; postoculars 2 + 2; temporals usually 2-2-2 on each side; tail length 19 to 27 per cent of total length; adults uniformly blue-green, blue-black, or black above, yellowish white to dark slate color below; chin often conspicuously lighter than venter; juveniles blue-gray, with 55 to 87 red-brown dorsal blotches that become

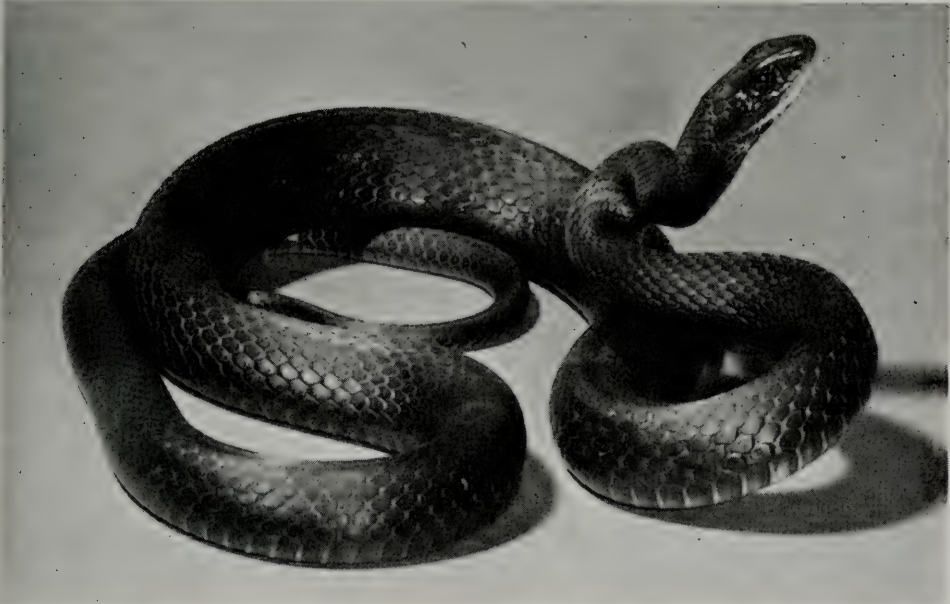


Fig. 188.—An adult *Coluber constrictor flaviventris* × *priapus* intergrade from Union County, Illinois. The color above may be blue-green, blue-black, or slaty black; below, yellowish white, pale gray, or slate color.

indistinct posteriorly, venter with brown markings; each hemipenis with large basal spines.

Variation.—Specimens of this species can be reliably sexed only by determining the presence or absence of hemipenes. The mean difference between the male and the female in number of caudals and ventrals consists of only 3 or 4 scales.

The juvenile is strikingly different from the adult, possessing reddish dorsal blotches that become progressively more closely crowded and more indistinct posteriorly. The tail is usually brownish gray, the venter

speckled with brown, and the side of the head spotted with white. Individuals 500 mm. or more in length usually retain the blotches only on the anterior portion of the body. The ventral spotting usually persists in specimens 700–800 mm. in length, although these snakes are unicolorous above. The proportion of tail length to total length does not vary ontogenetically.

Adult racers in extreme southern Illinois are usually blue-black above and slate color below, except for their conspicuously white chins, the edges of which are occasionally flecked with black. Occasional individuals

Table 57.—Geographic variation from north to south in Illinois *Coluber constrictor*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME NORTHERN ILLINOIS (15)		WEST-CENTRAL ILLINOIS (15)		EAST-CENTRAL ILLINOIS (15)		LOWER MISSISSIPPI BORDER (15)		EXTREME SOUTHERN ILLINOIS (25)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals.....	172–182	176.7	170–187	176.5	168–186	179.1	170–184	176.2	173–189	178.7
Caudals.....	71–87	79.6	76–89	83.6	76–96	85.6	82–95	87.7	84–97	90.9
Tail length as percentage of total length...	19.3–23.8	21.7	22.2–25.2	23.8	20.2–26.1	23.5	19.8–27.3	24.1	22.8–26.6	24.4

so colored occur in the Lower Mississippi Border division and Southern Division woodlands. In extreme northwestern Illinois some racers have decidedly greenish dorsums and yellow throats. Over most of the state, however, these features are combined so that the majority of specimens are blue-black above and grayish white beneath.

Juvenile racers in extreme southern Illinois have fewer body blotches than those from the remainder of the state. Six juveniles from the southernmost counties have 55 to 65 blotches (average 60); 15 juveniles from central Illinois have 59 to 77 blotches (average 69); and 4 juveniles from the northernmost counties in the state have 60 to 72 blotches (average 67).

In all Illinois specimens in which the hemipenes have been everted, basal hooks are present.

The major geographic variation is summarized in table 57. Individual variation in other scutellation for 85 specimens is as follows: scale rows 17-17-15 in 81 specimens, 18-17-15 in 4; supralabials 7 + 7 in 71 specimens, 7 + 8 in 10, 8 + 8 in 3, 6 + 6 in 1; infralabials 8 + 8 in 67 specimens, 8 + 9 in 9, 9 + 9 in 7, 7 + 7 in 2; preoculars 2 + 2 in all; postoculars 2 + 2 in 84 specimens, 2 + 3 in 1.

Habits.—The blue racer, although primarily terrestrial, does not hesitate to climb or to take to water when being pursued or when searching for food. It is frequently found under rocks or other objects, particularly when preparing to shed its skin or when temperatures are low. The racer is graceful, agile, and swift, and it is difficult to capture unless taken unaware. When cornered, it vibrates its tail, producing a rattling noise, and strikes savagely. Males reportedly may attack intruders during the mating season. Its food is remarkably varied, consisting of arthropods, annelids, amphibians, reptiles (even small turtles), birds, and mammals. In southern Illinois (Klimstra 1959c), its diet consists of insects (approximately 39 per cent), small mammals (32 per cent), amphibians (11 per cent), reptiles (8 per cent), birds (6 per cent), and miscellaneous items (4 per cent). In early spring, it feeds principally on mammals but from May through October subsists largely on insects. Captives are nervous, usually refusing food.

Data presented by Cagle (1942a) and Pope (1944b) indicate that the blue racer in

Illinois mates in May and early June. In late June and in July the 19 to 25 granular, white eggs are laid under rocks or within logs, and hatching occurs by early September. Cagle found the average dimensions of eggs in southern Illinois to be about 24×19 mm. A clutch from central Illinois, however, averaged 30×19 mm. The difference may be due to the different sizes and ages of the female snakes that laid the eggs.

Illinois Distribution.—The blue racer is almost state-wide in occurrence in Illinois, fig. 189. Records are sparse in the heavily farmed muck prairie of northern and central Illinois and completely lacking in the northeastern corner of the state. In places throughout most of the state where the for-



Fig. 189.—Distribution of *Coluber constrictor*. Vertical hatching indicates the presumed range of the subspecies *flaviventris* in Illinois; crosshatching, the area of intergradation between the subspecies *flaviventris* and *priapus*; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. There are small localized areas in the state where records are inexplicably absent. The lower map depicts the total range of the species in the United States.

est-edge habitat is widespread, racers are one of the most common large snakes.

Coluber constrictor priapus $\times$ *flaviventris* intergrades occur throughout the southern part of Illinois.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CHAMPAIGN COUNTY: Urbana (H. Garman 1892); COOK COUNTY: Chicago (Yarrow 1882a); DU PAGE COUNTY: Hinsdale (Stille & Edgren 1948); KANKAKEE COUNTY: Hopkins Park (Schmidt & Necker 1935); KNOX COUNTY: Galesburg (H. Garman 1892); MACOUPIN COUNTY: Standard City (Owens 1941); PEORIA COUNTY: Peoria (H. Garman 1892); UNION COUNTY: Cobden (H. Garman 1892); WILL COUNTY: Birds Ridge (Stille & Edgren 1948).

Masticophis Baird & Girard

This genus is known from northern South America northward into the United States and reaches its greatest abundance in southwestern United States and Mexico; four species, each with numerous subspecies, occur in the United States. One of these species inhabits extreme southwestern Illinois.

Masticophis flagellum flagellum (Shaw) Eastern Coachwhip

Coluber flagellum Shaw 1802:475 (type locality: Carolina and Virginia; revised to

Charleston, South Carolina, by Schmidt 1953).

Masticophis flagellum flagellum, Smith & Burger 1950:1.

Diagnosis.—A large, slender snake, fig. 190, usually with 17–17–13 rows of smooth scales; ventrals 186 to 207; caudals 91 to 119; supralabials usually 8 + 8; infralabials 10 + 10 or 11 + 11; preoculars 2 + 2; postoculars 2 + 2; temporals 2–2 on each side; frontal almost twice as wide anteriorly as posteriorly; adults uniform black above and below anteriorly, becoming gradually lighter on the tail; tail red (in Illinois and Missouri) to tan; dorsum in juveniles yellow-brown with dark crossbands, becoming indistinct posteriorly; venter in juveniles cream, with rows of brown spots; head in juveniles irregularly marked with white.

Variation.—From Illinois only two flattened specimens found dead on a road are extant. These were described (Smith & Burger 1950) as follows:

Both are juveniles, measuring 371 and 404 mm. in length. Scutellation is as follows: ventrals 207 and 200; subcaudals 95 and 91; scale rows 17–16–15 and 17–15–13.

Sexual variation and ontogenetic variation in *Masticophis* are presumably similar to those of *Coluber*.

Habits.—The eastern coachwhip is similar to the racer, sharing many of the attributes described for that species, including its varied food habits. No information is available on the life history of the eastern coachwhip in Illinois.

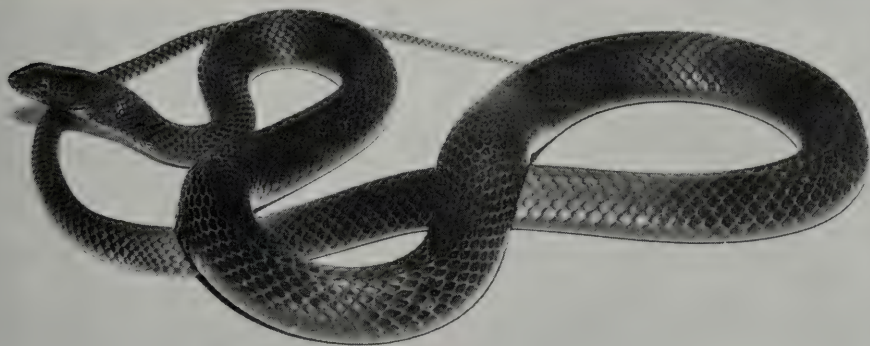


Fig. 190.—An adult *Masticophis flagellum flagellum* from Mayes County, Oklahoma. Examples from Illinois are jet black on the body with rose or tan increasing in extent toward the tip of the tail. (Photo by Isabelle Hunt Conant.)

Illinois Distribution.—This species is known in Illinois only in the vicinity of Fults, Monroe County, fig. 191. Considerable field work along the west-facing Missis-

sippi River bluffs has revealed only four individuals, but additional specimens will likely turn up when the Lower Mississippi Border counties are more thoroughly collected. An adult seen alive could not be captured. Another adult was found killed on the road, according to Douglas A. Rossman of the University of Florida (personal communication), but his specimen has not been available to me for scale counts.

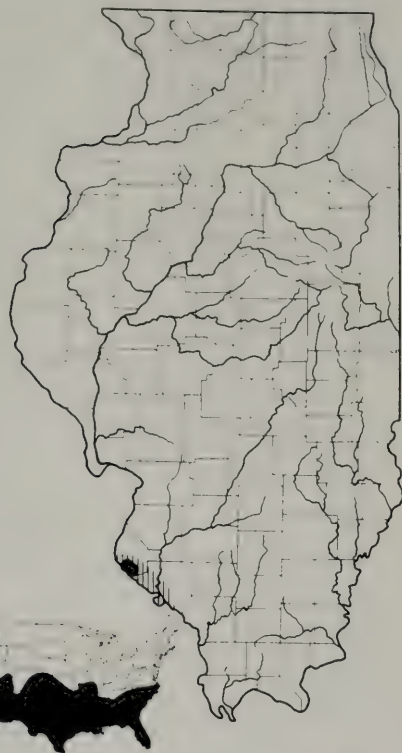


Fig. 191.—Distribution of *Masticophis flagellum*. Hatching indicates the presumed range of the subspecies *flagellum* in Illinois; solid circles indicate localities represented by specimens examined during this study. The lower map depicts the total range of the species in the United States.

ssippi River bluffs has revealed only four individuals, but additional specimens will likely turn up when the Lower Mississippi Border counties are more thoroughly collected. An adult seen alive could not be captured. Another adult was found killed on the road, according to Douglas A. Rossman of the University of Florida (personal communication), but his specimen has not been available to me for scale counts.

Elaphe Fitzinger

Five species of *Elaphe*, most of them with several well-marked subspecies, occur in the United States and Canada. The genus is

Elaphe guttata emoryi (Baird & Girard) Great Plains Rat Snake

Scotophis emoryi Baird & Girard 1853:157
(type locality: Howard Springs, Ellis County, Oklahoma).

?*Coluber emoryi*, Cope 1875:39.

Elaphe emoryi emoryi, Wright & Wright 1952:585.

Elaphe guttata emoryi, Schmidt 1953:196.

Elaphe laeta laeta, Smith & Burger 1950:1-2.

Diagnosis.—A large, moderately slender snake (largest Illinois specimen 1,172 mm. in total length), fig. 192, usually with 25-27-19 or 25-27-21 rows of scales; ventrals 210 to 234; caudals 55 to 80; supralabials usually 8 + 8; infralabials usually 11 + 11; preoculars 1 + 1; postoculars 2 + 2; temporals 2-2 on each side; groundcolor gray, olive, or light brown, with 25 to 48 dark brown or red-brown quadrangular, black-bordered dorsal blotches; tail with 8 to 20 spots or crossbars; a pair of prominent brown processes extending from first dorsal blotch onto the head and uniting on the frontal plate; venter prominently checkered with black and white.

Variation.—Males in this subspecies presumably differ from females in the greater average number of caudals.

A juvenile specimen from adjacent Missouri (Iron County) differs from adults primarily in the bolder pattern and in the lack of red or brown tint.

The six Illinois specimens available vary as follows: total length 867 to 1,172 mm.; tail length 14.1 to 16.2 per cent of total length (average 15.0 per cent); ventrals 210 to 221 (average 215.6); caudals 55 to 67 (average 62.8); dorsal blotches 39 to 48 (average 43.3); tail rings 12 to 16 (average 14); infralabials 11 + 11 in three, 10 + 11 in one, 9 + 9 in one, unknown in one. Two specimens are gray, prominently blotched with dark brown; four are decidedly reddish in both groundcolor and color of blotches. Four specimens have 25-27-19 and two have 25-27-21 rows of scales. Four have 8 + 8 supralabials, one has 7 + 7, and one is too damaged to permit counting of supralabials.

A specimen (INHS 6072) from Wayne County, Missouri, is 60 inches long, a foot longer than the largest previously recorded.



Fig. 192.—A juvenile *Elaphe guttata emoryi* from Reynolds County, Missouri. The ground-color is gray or light tan; the blotches are red-brown to brownish black.

Habits.—The Great Plains rat snake, although more terrestrial in habits than most other members of the genus, has considerable ability in climbing. Its food consists of birds and mammals, which it kills by constriction. Wild individuals vibrate their tails and strike, but captives are slow and even-tempered.

The species is oviparous. Little else is known of its life history.

Illinois Distribution.—Four of the specimens of this species extant from Illinois have been taken dead on the bluff road between Valmeyer, Monroe County, and Prairie du Rocher, Randolph County. This road is bordered on one side by the heavily farmed Mississippi floodplain, on the other by dry, precipitous rock bluffs. Two other specimens have been taken on the forested campus of Principia College near Elsah. Neill (1951*b*) reported having seen a specimen near East St. Louis, St. Clair County. Additional specimens may turn up in other Lower Mississippi Border counties, but it is unlikely that this western subspecies will be found elsewhere east of the Mississippi River, fig. 193.

The ranges of *Elaphe guttata guttata* and *E. g. emoryi* do not meet, even though the two forms are currently regarded as subspecies of a single species. The old published records for *guttata* in the Wabash Border counties are almost certainly based on misidentified specimens of the superficially similar *Lampropeltis calligaster*, as has been suggested in the list of deleted species. The kinship of *guttata* and *emoryi* assumes that intergradation occurred formerly but that the intergrade populations have since disappeared. The morphological relationship of these two subspecies, or incipient species, is obvious. The distributional relationships of *emoryi* focuses attention on another species of rat snake, *E. vulpina*, with similar habits and habitat requirements. These two species have more or less geographically complementary ranges in western Illinois, Missouri, and Kansas. In fact, both are known in the same Illinois county (Jersey) from localities that are scarcely 15 miles apart.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: MADI-



Fig. 193.—Distribution of *Elaphe guttata*. Hatching indicates the presumed range of the subspecies *emoryi* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States; the dots in the hiatus represent *guttata*.

SON COUNTY: Alton (Smith & Burger 1950); ST. CLAIR COUNTY: vicinity of East St. Louis (Neill 1951b).

Elaphe obsoleta (Say)

Eight subspecies of *Elaphe obsoleta* are recognized by some authorities, five by others. Two races are found in Illinois, intergrading across the southern fourth of the state.

Elaphe obsoleta obsoleta (Say)

Black Rat Snake Pilot Black Snake

Coluber obsoletus Say 1823:140 (type locality: Isle au Vache [sic] to Council Bluffs on the Missouri River; revised to Council Bluffs, Iowa, by Schmidt 1953); Jordan 1878:178.
Coluber obsoletus obsoletus, Yarrow 1882a: 102.

Elaphis obsoletus, H. Garman 1890:187 (part).

Elaphis obsoletus obsoletus, H. Garman 1892: 290-1.

Callopettis obsoletus, Surface 1906:158.

Elaphe obsoletus, Hankinson 1917:326.

Elaphe obsoleta, Pratt 1923:218.

Elaphe obsoleta obsoleta, Blanchard 1924b:536.
Coluber lindheimeri, Davis & Rice 1883a:29 (part).

Elaphis obsoletus lindheimeri, S. Garman 1883:152.

Coluber lindheimeri, Davis & Rice 1883b:36 (part).

Elaphe lindheimeri, Wright & Wright 1952: 585.

?*Coluber vulpinus nec* Baird & Girard, Hay 1892a:499.

?*Bascanion constrictor nec* Linnaeus, Praeger 1899:597-9.

Coluber obsoletus confinis, Cope 1877:64 (part).

Diagnosis.—A large, moderately stout-bodied snake (largest Illinois specimen 1,725 mm. in total length), fig. 194, with 23 to 27 rows of scales on the anterior part of body and 17 to 21 rows immediately preceding the anus, formula usually 25-25-19 or 25-27-19; scales feebly keeled; head wider than neck; preoculars usually 1 + 1; postoculars usually 2 + 2; supralabials usually 8 + 8; infralabials 11 to 13 per side; anterior temporals 2 per side; ventrals 225 to 242; caudals 67 to 89. Adult pattern of specimens over most of state consisting of dark groundcolor on the dorsum, with milky white occurring as mottling in the interspaces between the almost obsolete dorsal blotches and as light-edged scales on sides of neck; venter yellowish white, checkered and stippled with black; juvenile pattern consisting of 28 to 40 dark, rectangular dorsal blotches and 1 or 2 rows of alternating, dark lateral spots on a gray groundcolor; venter checkered with dark; tail 14 to 18 per cent of total length; ventral plates decidedly angular laterally.

Variation.—Sexual dimorphism in this snake is illustrated by 16 males and 11 females in table 58. The number of tail rings probably averages higher in males than in females.

Juveniles of the black rat snake differ from adults only in distinctness of pattern, a difference sufficiently great to confuse one unfamiliar with immature rat snakes. The young are prominently blotched with dark on a groundcolor of white or gray. Frequently the anterior dorsal blotches are connected by lateral processes of the blotches, and the lateral spots are usually linear on

the neck. In northern specimens the top of the head is variously mottled, but in southern specimens it is usually plain except for a prominent dark bar traversing the pre-

frontal plates, a pattern that distinguishes *obsoleta* from all other baby rat snakes.

Four populations, differing strikingly in color and pattern but with no correlated

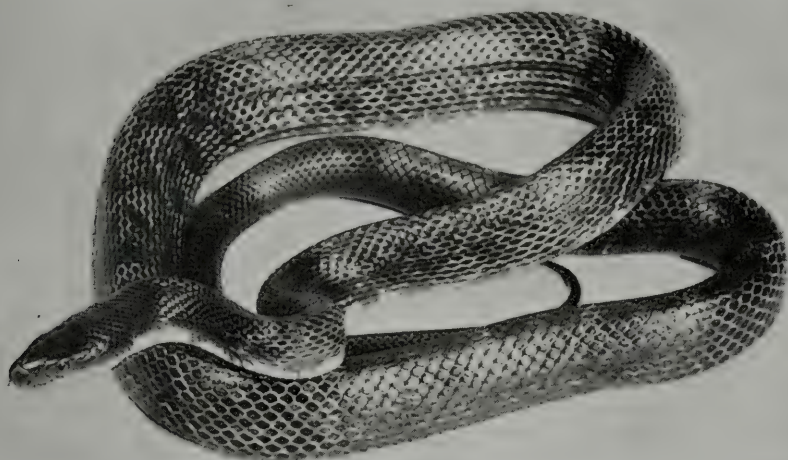


Fig. 194.—An adult *Elaphe obsoleta obsoleta*, blotched phase, from Cumberland County, Illinois. The groundcolor is gray or milky white, suffused with black; the square or quadrangular blotches are jet black.

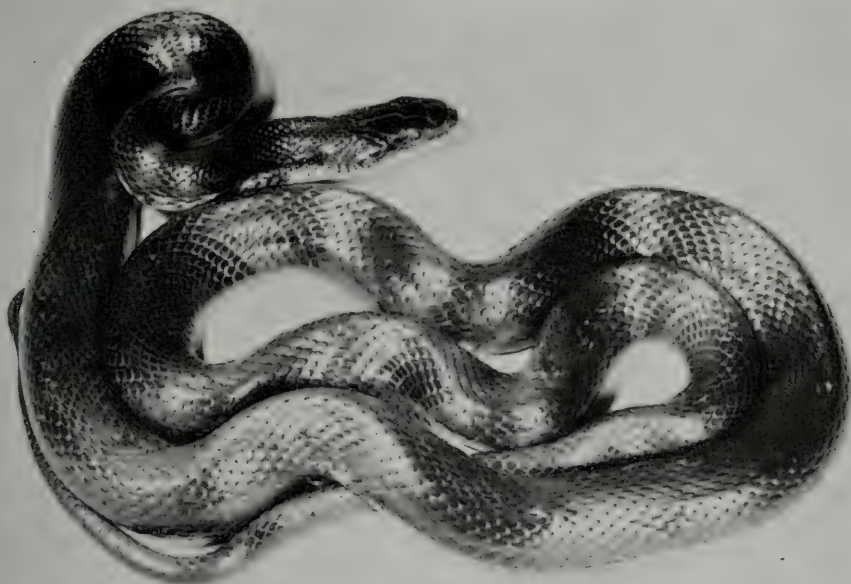


Fig. 195.—An adult *Elaphe obsoleta obsoleta*, black phase, from Union County, Illinois. The color above is black; below it is pink or red, with black markings.

differences in scutellation, are discernible within the state. (1) Extreme southern Illinois snakes (Alexander and Union counties) are intermediate in distinctness of pattern between the gray rat snake, *Elaphe obsoleta spiloides*, and the darker pilot black snake, *E. o. obsoleta*, and they are accordingly regarded as intergrades. (2) Individuals from the Lower Mississippi Border are usually jet-black above, with little or no trace of blotches, fig. 195. The underside posteriorly is a uniform blue-black; anteriorly the venter is usually pink or red, with black markings. (3) Specimens from the Mississippi Border between Monroe and Pike counties are exceedingly variable, ranging from the solid black phase just described to a conspicuously blotched pattern in which, however, the groundcolor is red, pink, or orange rather than gray. (4) Specimens from over most of Illinois (exclusive of the southern tip, the Lower Mississippi Border, and the Wabash and Ohio river counties) are black above, with definite light mottling at the points of the dorsal interspaces, fig. 194. The venter is yellowish white, with black markings. This fourth subrace is de-

scribed in the paragraph on diagnosis. There is some indication that specimens from extreme northwestern Illinois may be lighter in color. Examples from Jo Daviess and Carroll counties exhibit a tendency toward dorsolateral stripes that are light colored.

Except for the number of scale rows, which varies considerably among individuals, scutellation in *E. o. obsoleta* is remarkably uniform throughout Illinois. Toward the north there is a slight clinal reduction in number of ventral and caudal scales and a slight increase in the average number of body blotches. These gradients are summarized in table 59.

Individual variation in the scutellation of 47 specimens of *E. o. obsoleta* and *E. o. obsoleta* × *spiloides* intergrades is as follows: scale rows anteriorly 23 in 5 per cent of specimens, 24 in 7 per cent, 25 in 75 per cent, 26 in 2 per cent, 27 in 11 per cent; at mid-body 21 in 2.5 per cent, 24 in 2.5 per cent, 25 in 41 per cent, 26 in 7 per cent, 27 in 47 per cent; posteriorly 17 in 31 per cent, 18 in 5 per cent, 19 in 57 per cent, 21 in 7 per cent; supralabials 8 + 8 in 91.5 per cent, 9 + 9 in 6.4 per cent, 7 + 8 in 2.1 per cent;

Table 58.—Sexual variation in Illinois *Elaphe obsoleta*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (16)		FEMALES (11)	
	Range	Mean	Range	Mean
Ventrals.....	224-236	230.2	226-242	235.6
Caudals.....	77-89	81.6	67-77	73.4
Body blotches.....	28-40	32.0	24-35	30.2
Tail length as percentage of total length.....	15.7-18.4	16.9	14.4-17.3	16.0

Table 59.—Geographic variation from north to south in Illinois *Elaphe obsoleta obsoleta*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EXTREME NORTHWESTERN ILLINOIS (3 MALES, 3 FEMALES)		CENTRAL ILLINOIS (11 MALES, 4 FEMALES)		LOWER MISSISSIPPI BORDER (2 MALES, 5 FEMALES)		ALEXANDER-UNION COUNTIES (7 MALES, 8 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals.....	226-238	232.2	225-240	233.2	224-242	231.6	225-239	232.6
Caudals								
Male.....	79-85	81.5	77-89	81.5	81-83	82.0	78-87	82.1
Female.....	67-74	70.0	72-77	75.0	69-77	73.6	70-80	73.8
Body blotches.....	32-40	35.5	30-33	31.3	28-29	28.5	24-34	30.2

infralabials 10 + 11 in 2.1 per cent, 11 + 11 in 42.6 per cent, 11 + 12 in 29.8 per cent, 12 + 12 in 12.8 per cent, 12 + 13 in 8.5 per cent, 13 + 13 in 4.2 per cent; preoculars 1 + 1 in 98 per cent, 2 + 2 in 2 per cent; postoculars 2 + 2 in 96 per cent, 2 + 3 in 2 per cent, 3 + 3 in 2 per cent.

Habits.—The black rat snake, or pilot black snake, is an excellent climber. One specimen was found in a tree 40 feet above the ground; another was found on a concrete bridge support more than 20 feet off the ground. How the snake scaled the concrete bridge support is a mystery. In the fall black rat snakes congregate in the vicinity of rock outcrops, where they may hibernate with rattlesnakes and copperheads.

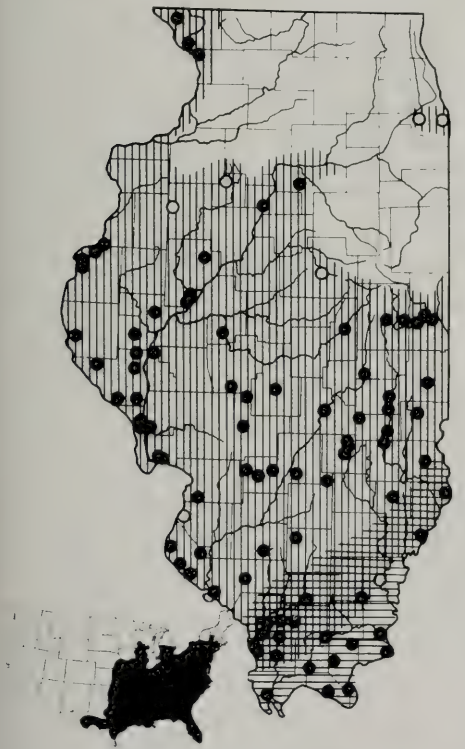


Fig. 196.—Distribution of *Elaphe obsoleta*. Vertical hatching indicates the presumed range of the subspecies *obsoleta* in Illinois; horizontal hatching, the presumed range of the subspecies *spiloides*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

In nature this snake is slow and deliberate. A disturbed individual often “freezes” in the position in which it is encountered, the kinks in its body producing the effect of a crooked stick. If annoyed, this snake raises its head, vibrates the tip of its tail rapidly, and lunges at the tormentor. A captive usually becomes tame and eats well. The species feeds primarily on birds and small mammals. Like other rat snakes, *obsoleta* is a powerful constrictor.

On several occasions the large eggs of this species have been found in wood rot. In almost every instance the approximately one dozen eggs were found in August or early September and contained snakes just ready to hatch.

Illinois Distribution.—The pilot black snake occurs over most of Illinois, fig. 196; it is sporadic in occurrence in predominantly prairie areas. It is common throughout the southern half of the state; it is not common in the Upper Mississippi River Border division. Apparently it is local and quite uncommon in northeastern Illinois. Wooded bluffs seem to provide choice habitat.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Dalton, Worth (Schmidt & Necker 1935); KNOX COUNTY: Galesburg (H. Garman 1892); McLEAN COUNTY: (H. Garman 1892); ST. CLAIR COUNTY: near St. Louis (Hurter 1893); STARK COUNTY: Elmira (Yarrow 1882a).

Elaphe obsoleta spiloides
Duméril, Bibron, & Duméril
Gray Rat Snake

- Elaphis spiloides* Duméril, Bibron, & Duméril 1854:219 (type locality: New Orleans, Louisiana).
- Coluber spiloides*, Wright & Wright 1952:585.
- Coluber obsoletus confinis*, Cope 1877:64 (part).
- Elaphe obsoleta confinis*, Cagle 1941:17.
- Elaphe obsoleta obsoleta* × *confinis*, Neill 1949a:8.
- Elaphis obsoletus obsoletus nec* Say, (H. Garman 1892:290 (part).
- Elaphe obsoleta*, Breckenridge 1944:120 (part).
- Coluber lindheimeri*, Davis & Rice 1883a:29 (part).
- Coluber lindheimeri*, Davis & Rice 1883b:36 (part).
- Elaphe obsoletus lindheimeri*, S. Garman 1884:27.



Fig. 197.—An adult *Elaphe obsoleta spiloides* from Pope County, Illinois. The groundcolor is gray; the blotches are black or dark brown.

Diagnosis.—A subspecies of *Elaphe obsoleta* (largest Illinois specimen 1,690 mm. in total length), fig. 197, differing from *E. o. obsoleta* in the retention of a distinctly blotched pattern throughout life. The 26 to 32 dark dorsal blotches and alternating lateral spots on a gray groundcolor can be counted readily on the largest adults.

Variation.—Sexual dimorphism and ontogenetic variation are evidently the same for *E. o. obsoleta* and *spiloides* except that *spiloides* adults do not differ so strikingly from juveniles.

Only 1 of 12 adult and subadult specimens of *spiloides* at hand is so dark that the body blotches cannot be readily counted. The counts of body blotches on the remaining 11 specimens range from 26 to 31 (average 29.4). For the 12 specimens, the tail length ranges from 14.7 to 18.4 (average 16.4) per cent of total length. Scutellation data are almost identical with those of Illinois specimens of *E. o. obsoleta* except for the slightly higher frequency of specimens with 27 scale rows on the anterior half of body. Ten specimens display the following variation: anterior scale rows 24 in 16.7 per cent, 25 in

33.3 per cent, 27 in 50.0 per cent; scale rows at mid-body 25 in 33.3 per cent, 27 in 66.7 per cent; posterior scale rows 17 in 50 per cent, 19 in 50 per cent; ventrals in males 227 to 238 (average 231.1), in females 230 to 235 (average 233.1); caudals in males 78 to 86 (average 82.0), in females 73 to 79 (average 76); supralabials 8 + 8 in all; infralabials 11 + 11 in 42 per cent, 11 + 12 in 29 per cent, 13 + 13 in 29 per cent; preoculars 1 + 1 in all.

Habits.—The gray rat snake, more often called chicken snake in Illinois, is similar in behavior, feeding habits, and reproductive habits to *E. o. obsoleta*. Individuals often enter buildings in search of rodents.

Illinois Distribution.—Individuals identical with Gulf Coast *spiloides* in pattern occur rather consistently in extreme southeastern Illinois, fig. 196. The habitat of *spiloides* is similar to that of *obsoleta*. Specimens referable to *obsoleta* × *spiloides* intergrades have been taken in Alexander, Hamilton, Jackson, Lawrence, Union, and Wabash counties.

Although undocumented by specimens, a published record for the following locality

is believed valid and is indicated on the distribution map by a hollow symbol: WHITE COUNTY: (Minton & Minton 1948).

***Elaphe vulpina vulpina* (Baird & Girard)**
Western Fox Snake

Scotophis vulpinus Baird & Girard 1853:75
(type locality: Racine, Wisconsin).

Coluber vulpinus, Yarrow 1882a:101.

Elaphe guttatus vulpinus, H. Garman 1892:
292-3.

Elaphe vulpinus, Hurter 1911:178.

Elaphe vulpina, Stejneger & Barbour 1917:84.

Elaphe vulpina vulpina, Conant 1940:10-1.

?*Coluber spiloides nec* Duméril, Bibron, &
Duméril, McLain 1899:3.

Diagnosis.—A large, moderately stout-bodied snake (largest Illinois specimen 1,297 mm. in total length), fig. 198, usually with 25-25-21 rows of feebly keeled scales; ventrals 192 to 210; caudals 53 to 69; supralabials usually 8 + 8; infralabials usually

11 + 11; preoculars usually 1 + 1; postoculars usually 2 + 2; anal plate divided; head wider than neck; adult pattern consisting of 34 to 42 red-brown dorsal spots on a yellow-gray groundcolor; an alternating row of brown lateral spots on each side of body; head coppery colored; venter yellow, boldly marked with black; juvenile similar except that yellow is lacking in groundcolor and blotches are dark chestnut or black.

Variation.—In the western fox snake the tail of the male is proportionately larger than that of the female. Other differences are the number of caudals (58 to 69, average 64, in males; 53 to 58, average 54.7, in females); number of tail rings (12 to 16, average 14, in males; 10 to 13, average 11.6, in females); and proportionate tail length (13.6 to 17.8, average 16.0, per cent of total length in males; 11.1 to 14.8, average 13.0, per cent of total length in females).



Fig. 198.—An adult *Elaphe vulpina vulpina* from Ford County, Illinois. The groundcolor is tan or yellow-brown; the blotches are chestnut brown.

Table 60.—Geographic variation in number of body blotches of Illinois *Elaphe vulpina*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHEASTERN ILLINOIS (9)		NORTHWESTERN ILLINOIS (13)		EAST-CENTRAL ILLINOIS (33)		WEST-CENTRAL ILLINOIS (4)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Body blotches.....	37-52	41.4	35-41	38.6	32-42	37.3	32-41	36.7

The average number of ventrals and body blotches is slightly greater in females than in males.

The juveniles are gray or white, prominently blotched with black or dark chestnut. Older individuals acquire a yellowish cast, and the blotches fade to a rich brown, which is often edged with black. The head becomes copper colored, and the head mottling tends to dim with age.

The only geographic variation discerned in this snake is a north-to-south trend toward a reduction in the number of body blotches. This is illustrated in table 60.

Individual variation in 40 specimens is not pronounced. Their scutellation data are as follows: 25 anterior scale rows in 97 per cent, 25 in 3 per cent; scale rows at mid-body 25 in 79.1 per cent, 27 in 10.5 per cent, 23 in 5.2 per cent, 24 in 2.6 per cent, 26 in 2.5 per cent; scale rows posteriorly 21 in 78.5 per cent, 19 in 11.0 per cent, 20 in 8.0 per cent, 23 in 2.5 per cent. Supralabials are 8 + 8 in 83 per cent, 8 + 9 in 11 per cent, 7 + 8 in 6 per cent; infralabials 11 + 11 in 61 per cent, 10 + 11 in 12 per cent, 11 + 12 in 9 per cent, 12 + 12 in 12 per cent, 9 + 9 in 6 per cent. Preoculars are 1 + 1 and postoculars 2 + 2 in 92 per cent, asymmetrical in 8 per cent.

On most specimens some dorsal blotches are as narrow as $2\frac{1}{2}$ scale lengths and other blotches, particularly anteriorly, are 5 scale lengths in width. The average width is approximately 4 scale lengths.

Habits.—The western fox snake is probably the most terrestrial member of the rat snake genus. Occasionally an individual can be found under the bark of standing dead trees or stumps 5 or 6 feet above the ground. The fox snake is abundant in the heavily farmed, black-soil prairies of central Illinois, and it apparently requires little vegetation cover, as it is often found along fence-rows and in pastures where little natural

cover remains. It can be found from early spring until late fall (one active specimen was collected December 4); there seems to be a burst of activity in early June in the Urbana region. During these few weeks many more snakes are seen dead on the roads than during the rest of the season. An angered fox snake vibrates the tip of its tail and strikes at intruders. In captivity it usually becomes tame, but frequently it refuses to eat. Sixteen individuals were once found in March in an old well, where they had survived the winter. Judged from material regurgitated by captives, the food consists largely of small mammals and birds.

Clutches of 8, 10, and 27 eggs of this snake have been found in soil and under objects on the ground. The egg shells adhere to each other, and the eggs are difficult to pull apart. Hatching occurs in late August and early September.

Illinois Distribution.—The western fox snake is common throughout the northern half of Illinois except in predominantly forested regions, fig. 199. This species apparently does well on the heavily cultivated muck prairies of north-central Illinois, from which many other snakes have been almost or entirely exterminated.

The record of a single adult (INHS 1317) from Jerseyville, Jersey County, would be open to question except that the field tag is still attached to the specimen. It is typical in all respects except for a rather longer head. Jersey County includes some prairie, but the countryside does not appear to be typical *vulpina* habitat.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: BUREAU COUNTY: Milo (Conant 1940); COOK COUNTY: Argo (Schmidt & Necker 1935); Bloom Township (Necker 1939c); Chicago Ridge (Conant 1940); Evanston.

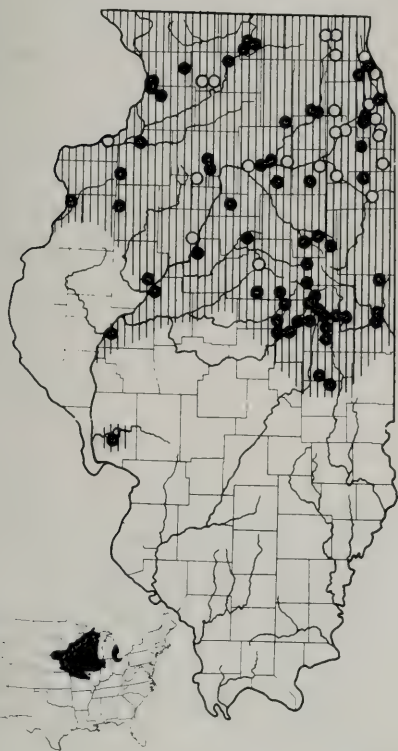


Fig. 199.—Distribution of *Elaphe vulpina*. Hatching indicates the presumed range of the subspecies *vulpina* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Hazelcrest (Schmidt & Necker 1935); Homewood (Conant 1940); Lemont (Necker 1939c); Du PAGE COUNTY: Du Page Township (Necker 1939c); Naperville (Schmidt & Necker 1935); GRUNDY COUNTY: Pequot (Necker 1939c); KANKAKEE COUNTY: Aroma Township (Necker 1939c); LAKE COUNTY: Barrington (Necker 1939c); Beach (Schmidt & Necker 1935); Sayer Bog, Volo (Necker 1939c); LA SALLE COUNTY: 4 mi. E La Salle, 3 mi. E Marseilles (Burt & Hoyle 1934); McHENRY COUNTY: McHenry (Schmidt & Necker 1935); McLEAN COUNTY: Bloomington (McLain 1899); Normal (H. Garman 1892); OGLE COUNTY: Polo, White Pines State Park (Conant 1940); PEORIA COUNTY: Peoria (H. Garman 1892); ROCK ISLAND COUNTY: Rock Island (Yarrow

1882a); WILL COUNTY: 4 mi. N Beecher (Burt & Hoyle 1934); Custer Park, Joliet (Schmidt & Necker 1935); Romeoville (Conant 1940); Wheatland Township (Schmidt & Necker 1935).

Pituophis Holbrook

This strictly North American genus includes, in the United States, one species with 10 subspecies, or two species, each with several subspecies, the number of species and subspecies contingent upon the viewpoint of the specialist. One subspecies occurs in Illinois.

Pituophis melanoleucus sayi (Schlegel) Bullsnake

Coluber sayi Schlegel 1837:157 (type locality: Missouri; revised to vicinity of St. Louis, Missouri, by Schmidt 1953).

Pityophis sayi sayi, Cope 1875:39.

Pityophis catenifer sayi, S. Garman 1883:151.

Pityophis sayi, Hay 1857a:10.

Pituophis sayi, Jordan 1888:196.

Pituophis sayi sayi, Necker 1933:8.

Pituophis catenifer sayi, Edgren & Stille 1948:5.

Pityophis catenifera sayi × *bellona*, H. Garman 1892:286–9.

Pituophis malansleucus, Brendel 1857:254.

Pityophis catenifer catenifer nec Blainville, H. Garman 1892:286–9.

Diagnosis.—A large, moderately stout-bodied snake (largest Illinois specimen 1,880 mm. in total length), fig. 200, with 26 to 31 rows of scales on the anterior part of the body, 29 to 33 rows at mid-body, and 21 to 25 rows on the posterior part of the body; scales feebly keeled; head wider than neck; rostral plate enlarged and projecting forward; supralabials 8 or 9 on each side, usually with sutures heavily margined with black; infralabials 11 to 13 on each side; preoculars usually 1 + 1 and postoculars 3 + 3 or 4 + 4; prefrontal plates 4; ventrals 213 to 233; caudals 48 to 61; anal plate entire; groundcolor yellow, with 36 to 54 conspicuous dorsal body blotches that alternate with two rows of lateral spots on each side; anterior and posterior body blotches black, mid-body blotches brown; tail with 8 to 15 black rings; venter yellow, checkered with black.

Variation.—The male bullsnake differs from the female in the greater number of caudals, smaller number of ventrals, and

relatively greater tail length. Ten males have 213 to 230 ventrals (average 221.9) and 54 to 61 caudals (average 58.2); tail length ranges from 10.5 to 14.0 (average 12.6) per cent of total length. Ten females have 222 to 233 ventrals (average 227) and 48 to 57 caudals (average 52.1); tail length ranges from 10.1 to 13.0 (average 11.4) per cent of total length.

The juveniles differ from the adults in duller coloration and possession of almost unicolorous body blotches. The groundcolor is usually dull tan, rather than yellow, and the blotches at mid-body are usually black, rather than brown.

The average number of dorsal blotches in

this snake is greater in specimens from northern localities than from elsewhere in the state. Twenty-three central Illinois specimens range from 36 to 54 (average 48.5) in blotch counts and from 8 to 15 (average 11.3) in tail rings; eight northwestern Illinois specimens range from 46 to 54 (average 50.1) in blotch counts and from 11 to 14 (average 11.5) in tail rings.

Other variation, which is neither sexual nor geographic, is as follows: anterior scale rows 26 to 31 (average 28); scale rows at mid-body 29 to 33 (average 31.1); posterior scale rows 21 to 25 (average 23.4); upper labials 8 + 8 in 20 per cent of specimens at hand, 8 + 9 in 40 per cent, 9 + 9 in 35 per



Fig. 200.—An adult *Pituophis melanoleucus sayi* from Mason County, Illinois. The groundcolor is bright yellow or tan; the blotches are black anteriorly and posteriorly but rich brown at mid-body.

cent, and 6 + 8 in 5 per cent; infralabials 12 + 12 in 40 per cent, 11 + 12 in 10 per cent, 12 + 13 in 15 per cent, 13 + 13 in 25 per cent, 11 + 13 in 5 per cent, and 13 + 14 in 5 per cent; azygous scales absent in 39 per cent, 1 azygous scale in 50 per cent, 2 scales in 11 per cent. Most Illinois specimens are prominently blotched; a few individuals appear faded.

Habits.—The large bullsnake, although essentially a terrestrial reptile, climbs and burrows readily in search of food. When first encountered, a bullsnake vibrates its tail and hisses loudly, with its mouth partially opened. It is rather vicious, but captives usually become tame and feed well. The food of the bullsnake consists of mammals, birds, and bird eggs. It is a powerful constrictor and is of considerable economic importance because of its predation on injurious rodents.

The species is oviparous. Reproductive habits are probably similar to those of the rat snakes in the genus *Elaphe*.

Illinois Distribution.—The distribution pattern, fig. 201, of the bullsnake is one of the most puzzling of those of Illinois reptiles. The species occurs commonly in the extensive sand prairies of central and northern Illinois and less commonly in the black-soil prairies east of the sand areas to at least De Witt County. Although bullsnakes are occasionally found in small wooded areas, they apparently do not occur in extensively forested regions. The paucity of records just west of the Illinois River is not readily explained; the available evidence suggests that bullsnakes are uncommon there. In northeastern Illinois, bullsnakes are closely restricted to the Kankakee sand area.

A bullsnake (FAS 19) reportedly found near Urbana, Champaign County, and a published record for Champaign (Stull 1940) have not been plotted on the map, fig. 201, since there is some possibility that the specimens might have been collected elsewhere. It hardly seems possible that this large, spectacular species could occur in a region so well studied and still be known from only two examples. The published record by Gage (1914) for Richland County has been dismissed as probably being based on misidentification, inasmuch as she reported the bullsnake as common there but failed to mention the abundant prairie kingsnake. Richland County does not appear to contain

suitable *Pituophis* habitat. However, a small relict colony of *Pituophis* is known in the sandy soil of Knox County, Indiana, a few miles to the east of Richland County. Old published records for *Pituophis* in Madison and St. Clair counties are believed to be

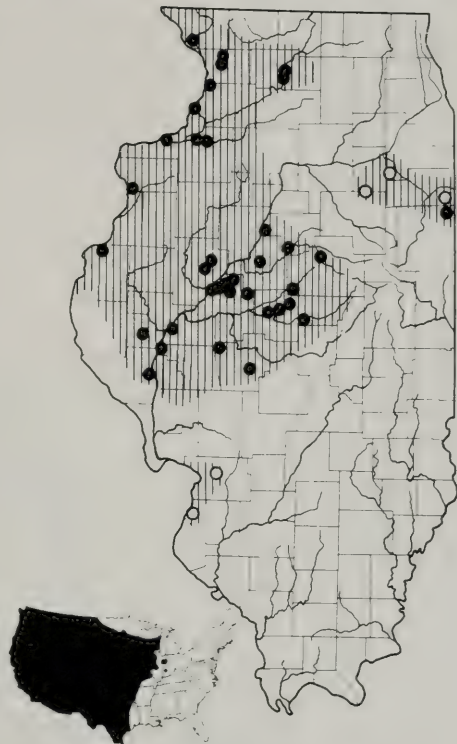


Fig. 201.—Distribution of *Pituophis melanoleucus*. Hatching indicates the presumed range of the subspecies *sayi* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the bullsnake complex of subspecies in the United States. It does not include the pine snakes.

valid, the absence of museum specimens notwithstanding.

Sometimes bullsnakes are found under objects on the ground, but the majority of the bullsnakes taken as specimens are discovered while they are crossing roads or they are encountered in cultivated fields or sand prairies.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: GRUNDY COUNTY: vicinity of Dwight (Stille &

Edgren 1948); KANKAKEE COUNTY: Pembroke Township (Schmidt & Necker 1935); MADISON COUNTY: (Stull 1940); ST. CLAIR COUNTY: opposite St. Louis (Hurter 1903); WILL COUNTY: Custer Park (Stille & Edgren 1948).

Lampropeltis Fitzinger

This New World genus is represented in the United States by seven species, some of which have several well-marked subspecies. Five species and subspecies are known in Illinois. Many of the subspecies are sufficiently distinctive in general appearance to suggest different species of snakes, but they are known to have geographically complementary ranges and to interbreed where their ranges meet.

Lampropeltis calligaster calligaster (Harlan) Prairie Kingsnake

Coluber calligaster Harlan 1827:359 (type locality: Missouri; revised to vicinity of St. Louis, Missouri, by Schmidt 1953).

Ophibolus calligaster, Cope 1875:37.

Lampropeltis calligaster, Jordan 1888:197.

Lampropeltis calligaster calligaster, P. W. Smith 1947:34.

Ophibolus evansii Kennicott 1859:99 (type locality: prairies of central Illinois).

Coluber emoryi nec Baird & Girard, Cope 1875:39.

Ophibolus rhombomaculatus nec Holbrook, Davis & Rice 1883a:29.

Lampropeltis rhombomaculatus nec Holbrook, Jordan 1888:197.

?*Pituophis catenifer sayi* nec Schlegel, Gaige 1914:4.



Fig. 202.—An adult *Lampropeltis calligaster calligaster* from Sangamon County, Illinois. The groundcolor is gray, tan, brown, or light olive; the frequently indistinct blotches are dark gray or brown. Some individuals appear almost unicolorous; others, especially those in southeastern Illinois, have distinct red-brown blotches.

Diagnosis.—A large, moderately slender snake (largest Illinois specimen 1,327 mm. in total length), fig. 202, usually with 25 scale rows on the anterior half of the body and 19 or 21 posterior rows; scales smooth; head little wider than neck; eyes small; supralabials 7 + 7 or 8 + 8; infralabials 9 to 11 on each side; preoculars 1 + 1; postoculars 2 + 2; ventrals 194 to 213; caudals 41 to 57; anal plate entire; groundcolor gray, brown, or straw-color with 41 to 64 dark dorsal body blotches and two or three

Table 61.—Sexual dimorphism in Illinois *Lampropeltis calligaster calligaster*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (24)		FEMALES (13)	
	Range	Mean	Range	Mean
Ventrals.....	194-210	203.2	195-213	206.3
Caudals.....	44-57	50.0	41-48	44.8
Tail length as percentage of total length.....	11.3-14.7	13.3	11.9-14.4	12.8
Tail rings.....	10-21	14.1	9-14	12.1

Table 62.—Blotch count of male and female specimens of Illinois *Lampropeltis calligaster calligaster*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHERN ILLINOIS				EAST-CENTRAL ILLINOIS				WEST-CENTRAL ILLINOIS			
	Males (6)		Females (4)		Males (17)		Females (14)		Males (9)		Females (4)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Blotch count	41-51	45.1	42-49	45.0	43-57	49.1	40-51	45.9	44-64	49.3	43-46	44.7

Table 63.—Geographic variation in Illinois *Lampropeltis calligaster calligaster*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SOUTHERN ILLINOIS (9 MALES, 5 FEMALES)		WEST-CENTRAL ILLINOIS (6 MALES, 5 FEMALES)		EAST-CENTRAL ILLINOIS (6 MALES, 5 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	200-210	205.3	197-207	203.0	194-207	200.5
Female.....	210-213	211.5	199-209	205.5	195-209	202.0
Caudals						
Male.....	44-53	49.6	47-57	52.1	46-51	48.2
Female.....	45-47	46.0	42-47	45.0	41-48	43.5
Tail length as percentage of total length						
Male.....	12.0-13.8	12.8	12.8-14.7	13.8	11.3-13.4	12.8
Female.....	12.0-13.6	12.9	12.1-14.4	13.1	11.9-13.1	12.5
Body blotches.....	41-51	45.0	43-64	47.6	43-57	48.9

series of dark spots on each side, alternating with the dorsal blotches; dorsal blotches extending ventrad to scale row 5, 6, or 7; venter gray-white or yellowish gray, with irregular and usually dim dark markings.

Variation.—In the prairie kingsnake, sexual dimorphism in scutellation is slight, but it can be detected by comparing averages, table 61.

In central Illinois specimens, there is a tendency toward a higher blotch count in males than in females; in southern Illinois specimens, blotch count means are identical in the two sexes. This characteristic is summarized in table 62.

The juvenile differs from the adult chiefly in color and prominence of pattern. The baby kingsnake has distinct reddish blotches, with black borders above; the venter is distinctly marked with black. In pattern the young *calligaster* closely resembles the young of the related milk snake, *Lampropeltis triangulum*, but it can be distinguished by the narrower blotches, which extend ventrad only to the fifth or sixth scale row (fourth or lower in the milk snake).

Except for the tendency toward greater sexual dimorphism in the northern part of the range, no geographic variation is obvious for the prairie kingsnake in Illinois. Variation data for three samples are summarized in table 63.

The number of scale rows anteriorly is distributed as follows: 23 in 7.5 per cent of specimens, 24 in 7.5 per cent, 25 in 77.5 per cent, 26 in 7.5 per cent; at mid-body, 23 in 2.5 per cent, 25 in 90.0 per cent, 26 in 5.0 per cent, 27 in 2.5 per cent; posteriorly, 19 in 39.5 per cent, 20 in 7.5 per cent, 21 in 53.0 per cent. Supralabials are 6 + 7 in 2.8 per cent of the specimens, 7 + 7 in 50.2 per cent, 7 + 8 in 30.4 per cent, 8 + 8 in 11.0 per cent, 7 + 9 in 2.8 per cent, and 8 + 9 in 2.8 per cent. Infralabials are 9 + 9 in 31.0 per cent of the specimens, 9 + 10 in 33.0 per cent, 9 + 11 in 2.8 per cent, 10 + 10 in 22.0 per cent, 10 + 11 in 5.5 per cent, 11 + 11 in 2.8 per cent, and 12 + 13 in 2.8 per cent. Preoculars are 1 + 1 in 94 per cent of the specimens, 1 + 2 in 3 per cent, 2 + 2 in 3 per cent; postoculars are 2 + 2 in 91 per cent, 2 + 3 in 6 per cent, and 3 + 3 in 3 per cent.

Occasional adult specimens retain a well-pronounced pattern of reddish blotches with black margins. A few individuals are al-

most unicolorous, only traces of the blotches being evident; in some of these are dim, longitudinal light bands in the form of a pair of paravertebral bands and a lateral stripe. The majority of adults and subadults are distinctly blotched, but the pattern is not in great contrast to the groundcolor.

A specimen (from Springfield) in the Chicago Academy of Sciences is aberrant in pattern in that a pair of dorsolateral dark stripes extend almost the length of the body, replacing the usual blotched pattern. The spots on the tail have not fused to form stripes.

Another aberrant specimen (INHS 6189) collected December 2, 1951, 3 miles south of Philo, Champaign County, suggests a *triangulum* × *calligaster* hybrid. This snake, a female, 575 mm. in total length, has 24–25–19 scale rows, 203 ventrals, 51 caudals, 7 + 8 supralabials, 10 + 10 infralabials, 1 + 2 oculars, and 42 dorsal body blotches. The chin and venter are prominently checkered with black and white, and the dorsal blotches extend ventrad onto the fourth and fifth scale rows anteriorly. Except for the presence of a prominent sub-orbital dark spot, the head pattern is typical of *calligaster*.

Habits.—The prairie kingsnake shows a preference for old fields. In bluegrass plots the species is easily confused with the racer, as it sometimes moves so fast that the blotched pattern is not evident. Captured individuals vibrate the tail tip and usually try to bite. Most captives become tame, but they usually do not feed well in cages. This kingsnake occasionally hibernates in road embankments. On mild days some individuals may be enticed from their hibernating chambers by the winter sun. They have been found active in November, December, and February, and they are among the first snakes to be seen in early March. Captives have disgorged small mammals, and one specimen regurgitated an equally large prairie kingsnake. Klimstra (1959a) noted that, in southern Illinois, small mammals make up 68.6 per cent of the diet and that amphibians, reptiles, birds, and insects constitute the remaining percentage.

A captive specimen from central Illinois laid 9 eggs on July 5. Cagle (1942a) reported a clutch of 9 eggs for a southern Illinois specimen. Young of the year are in evidence in September.

Illinois Distribution.—The prairie kingsnake, abundant in prairie regions in the southern two-thirds of Illinois, is a characteristic species of the Outlier Prairies of the Southern Division, fig. 203. The species ex-

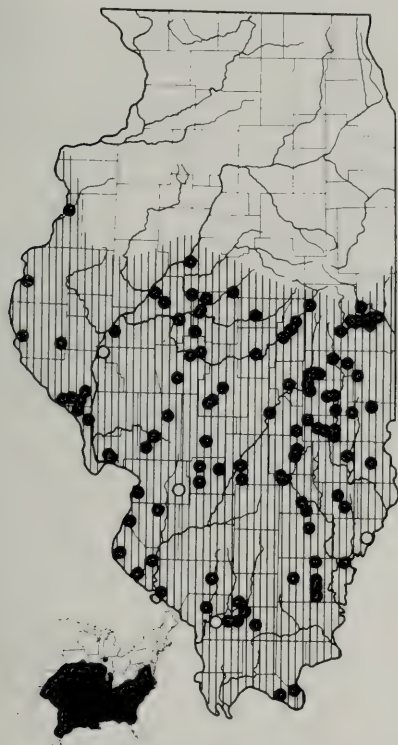


Fig. 203.—Distribution of *Lampropeltis calligaster*. Hatching indicates the presumed range of the subspecies *calligaster* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the species in the United States.

tends northward on the central prairies to Tazewell and McLean counties, but it is much less common on the heavily farmed black-soil prairies and apparently is restricted to small areas of poorer soil that support a brushy cover. *L. calligaster* has not been found in the vicinity of Urbana. The prairie kingsnake and the ecologically similar fox snake overlap in distribution, but they may not compete inasmuch as the fox snake seems to thrive in heavily cultivated black soils.

Although *L. calligaster* occurs in the extreme southern tip of the state, it is evidently

uncommon in the predominantly forested regions there.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Murphysboro (Ditmars 1945); MADISON COUNTY: Highland (Hurter 1893); MORGAN COUNTY: Meredosia (Weed 1923); WABASH COUNTY: Mount Carmel (Schneck 1880a).

Lampropeltis getulus (Linnaeus)

Nine subspecies of this transcontinental species occur in the United States. Two inhabit Illinois, intergrading in the southern third of the state.

Lampropeltis getulus holbrooki Stejneger Speckled Kingsnake

Lampropeltis holbrooki Stejneger 1902:150
(type locality: valley of the Mississippi);
Stejneger & Barbour 1917:88.

Lampropeltis getulus holbrooki, Hurter 1911: 185.

Ophibolus getulus sayi, Cope 1875:37.

Lampropeltis getulus sayi, Jordan 1888:196.

Diagnosis.—A large, moderately slender snake (largest Illinois specimen 1,232 mm. in total length), fig. 204, usually with 21 anterior and 17 or 19 posterior rows of smooth scales; anal plate entire; head little wider than neck; supralabials usually 7 + 7; infralabials usually 9 + 9; preoculars 1 + 1, postoculars, 2 + 2; 2, 3, or 4 temporals on each side; ventrals 201 to 219; caudals 41 to 56; groundcolor above black, each scale containing a yellow spot, sometimes dots fused to form traces of crossbands; venter checkered with black and yellow, the black usually predominating; labial sutures heavily margined with black.

Variation.—Since the two Illinois subspecies of *Lampropeltis getulus* are identical in scutellation and proportions, variation for both races as well as intergrades is included here.

Twelve males have 42 to 56 (average 49.5) caudals; tail length ranges from 11.2 to 14.6 (average 12.9) per cent of total length. Twelve females have 41 to 49 (average 45.2) caudals; tail length ranges from 10.7 to 14.5 (average 12.1) per cent of total length.



Fig. 204.—An adult *Lampropeltis getulus holbrooki* from Randolph County, Illinois. The groundcolor is blue-black; each scale contains a round yellow or yellowish white spot.

Juveniles of *L. g. holbrooki* differ from adults in that some of their middorsal scales lack light dots. Prominent light crossbands as well as light spots are present in juveniles but sometimes difficult to count because of their irregularity. Three juveniles have 69, 78, and 82 crossbands on the body. Adults are too speckled for reliable counts to be made. Twelve specimens of Illinois *L. g. niger*, both juveniles and adults, have 40 to 56 crossbands. Otherwise, juveniles of *holbrooki* are indistinguishable from those of *niger*; the possible difference in number of crossbands needs checking with additional specimens.

Individual variation in a sample of 25 specimens of *L. getulus* is as follows: anterior scale rows 19 in 16 per cent, 20 in 24 per cent, 21 in 60 per cent of specimens; scale rows at mid-body 21 in 88 per cent, 22 in 4 per cent, 23 in 8 per cent; posterior scale rows 17 in 17 per cent, 18 in 4 per cent, 19 in 71 per cent, 20 in 8 per cent; ventrals 201 to 218 (average 211.7); supralabials 7 + 7 in 96 per cent, 8 + 7 in 4 per cent; infralabials 7 + 8 in 4 per cent, 8 + 8 in 4 per cent, 8 + 9 in 8 per cent, 9 + 9 in 76 per cent, and 9 + 10 in 8 per cent.

Habits.—This powerful kingsnake is slow and deliberate in its movements. When first encountered, an individual vibrates its tail and strikes viciously. Captives usually become tame quickly, however, and they are popular as pets. The species is most often encountered under flat rocks or logs or found crossing roads. Captive individuals feed on other snakes, birds, and mammals, all of which are constricted by the muscular body of the kingsnake before being swallowed.

A large captive female deposited 13 large, smooth eggs on July 19 and 20. These eggs, strongly adherent, averaged 21×37 mm. By October 12 they had increased in size to an average of 39×26 mm. but had not hatched. Each egg contained a well-formed but dead snake. Cagle (1942a) recorded that a clutch of 9 eggs was laid in mid-June and was hatched in mid-August.

Illinois Distribution.—The speckled kingsnake probably occurs sporadically throughout western Illinois south of Peoria, fig. 206. The requisite habitat of wooded, hilly terrain is so restricted in most of that part of the state that the rarity of *holbrooki* in collections is not surprising. Though the

Illinois range of *holbrooki* is more extensive than that of the closely related *niger*, *holbrooki* is apparently much less common. Most of the Illinois specimens have been taken in the Lower Mississippi Border division.

Intergradation of *holbrooki* and *niger* is exhibited by specimens from extreme southwestern Illinois, and intergrades probably occur in most of the Southern Division. Single juveniles cannot be referred with certainty to either race, since the subspecific difference is one of pattern only. In a series from southern Union County, the *niger* influence predominates. In material from Jackson and northern Union counties, the two pattern types are about equally distributed. In eastern Illinois, no intergrades have been taken. Specimens from Effingham County are typical *holbrooki*; those from adjacent Cumberland and Jasper counties are typical *niger*.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Elkhaville, Makanda (Cagle 1942a); Murphysboro (Ditmars 1945); PEORIA COUNTY: Peoria (H. Garman 1892); ST. CLAIR COUNTY: (Hurter 1911).

***Lampropeltis getulus niger* (Yarrow)**
Black Kingsnake

Ophibolus getulus niger Yarrow 1882b:438
(type locality: Wheatland, Indiana); Yarrow 1882a:93.

Lampropeltis getulus niger, Blanchard 1921: 18, 43-8.

Lampropeltis getulus nigra, Pratt 1923:221.

Ophibolus getulus sayi nec Holbrook, Yarrow 1882a:93 (part).

Lampropeltis getulus holbrooki nec Stejneger, Myers 1926:291.

Diagnosis.—A subspecies of *Lampropeltis getulus* (largest Illinois specimen 1,369 mm. in total length), fig. 205, differing from *L. g. holbrooki* only in detail of dorsal pattern: speckling reduced to 40 to 56 narrow crossbands, each of which forks on the side; some of lateral scales with light centers, others black.

Variation.—Sexual variation is identical in *holbrooki* and *niger*. Juveniles of *niger* differ from the adults only in having a somewhat brighter pattern.

Comparison of means for counts and measurements of three specimens from Cumberland and Jasper counties and 15 from extreme southeastern Illinois reveals no trends in geographic variation. Individual variation in scutellation and proportions for

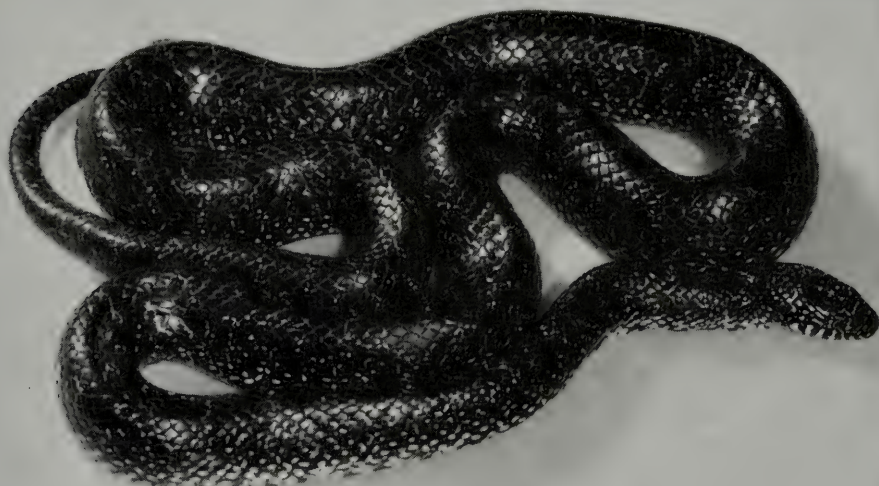


Fig. 205.—An adult *Lampropeltis getulus niger* from Alexander County, Illinois. The groundcolor is blue-black; small dots of yellowish white tend to form crossbars at regular intervals.

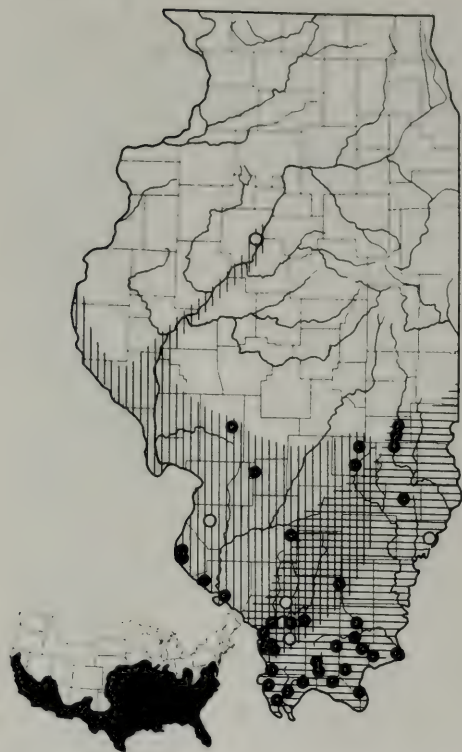


Fig. 206.—Distribution of *Lampropeltis getulus*. Vertical hatching indicates the presumed range of the subspecies *holbrooki* in Illinois; horizontal hatching, the presumed range of the subspecies *niger*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the species in the United States.

the species is summarized under *L. g. holbrooki*. Individuals vary in pattern from those that are almost uniformly black to those, usually juveniles, in which the crossbands are almost a scale length in width.

Habits.—The black kingsnake is similar to the speckled kingsnake in behavior and reproductive habits. A captive female deposited 13 eggs in early July. The 13 young hatched on August 30 and 31.

Illinois Distribution.—The black kingsnake occurs throughout eastern Illinois from Edgar County southward, fig. 206. The number seen dead on highways indicates that this snake is rather common in southeastern Illinois.

Although undocumented by specimens, published records for the following localities

are believed valid; most are indicated on the distribution map by hollow symbols: UNION COUNTY: Dug Hill (H. Garman 1892); WABASH COUNTY: Mount Carmel (Yarrow 1882*b*).

Lampropeltis triangulum (Lacépède)

Ten subspecies of *Lampropeltis triangulum* are currently recognized. Two particularly well-marked races occur in Illinois. They intergrade in a wide belt across the central part of the state; in this area their characters show a bewildering overlap.

The trivial name *doliata* of Linnaeus is applied to the milk snakes by most recent authors, who believe that *doliata*, which has priority over *triangulum*, refers to a milk snake. The name *triangulum* is retained for the species by other authors who believe that the description of *doliata* better fits the scarlet snake of the genus *Cemophora*.

Lampropeltis triangulum triangulum (Lacépède)

Eastern Milk Snake

Coluber triangulum Lacépède 1788:86 (type locality: America; revised to vicinity of New York City, New York, by Schmidt 1953).

Lampropeltis triangulum triangulum, Blanchard 1921:108, 205.

Lampropeltis triangulum, Ditmars 1929:90.

Lampropeltis doliata triangulum, Wright & Wright 1952:585.

Lampropeltis triangulum triangulum × *syspila*, Langebartel 1947:27–8.

Ophibolus doliatus triangulus, Yarrow 1882*a*: 91.

Ophibolus triangulus triangulus, H. Garman 1892:295–6.

Lampropeltis doliatus triangulus, Surface 1906:178.

Osceola doliata triangula, Cope 1900:886.

Ophibolus doliatus nec Linnaeus, H. Garman 1892:299.

Lampropeltis doliatus nec Linnaeus, Hankinson 1917:327.

Ophibolus eximus, Kennicott 1855:592.

Diagnosis.—A medium-sized, moderately slender snake (largest Illinois specimen 1,110 mm. in total length), fig. 207, usually with 21 anterior and 17 or 19 posterior rows of smooth scales; anal plate entire; head little wider than neck; supralabials usually 7 + 7; infralabials usually 9 + 9; preoculars 1 + 1; postoculars 2 + 2; ventrals 198 to 215; caudals 36 to 52; groundcolor gray or white, with 33 to 46 black-margined, brown dorsal blotches alternating with 1 or 2 rows

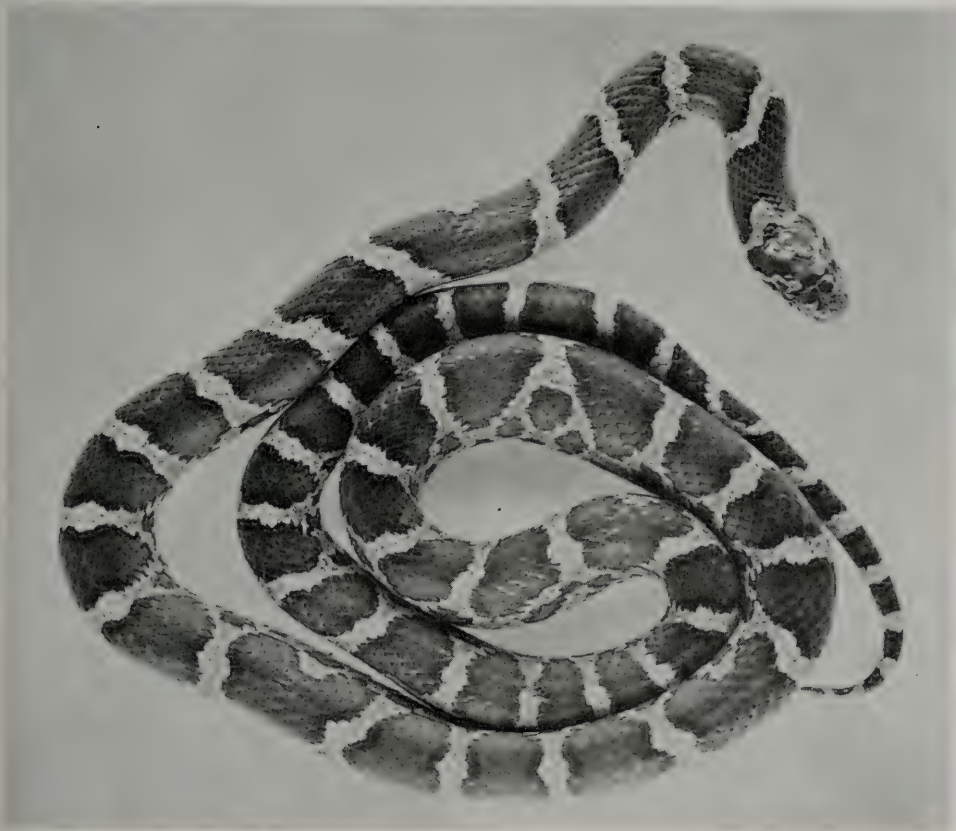


Fig. 207.—A juvenile *Lampropeltis triangulum triangulum* from Lake County, Illinois. The groundcolor is light gray or tan; the blotches are red-brown or dark brown, heavily margined with black.

of lateral spots on each side; dorsal blotches extending ventrad to scale row 2, 3, 4, or 5; venter prominently checkered with black and white; head pattern a dark chevron-shaped marking.

Variation.—In *Lampropeltis triangulum triangulum* the average number of caudals is greater in males than in females and, surprisingly, males have a slightly higher blotch count on the body. The usual dimorphism in proportionate tail length and number of tail rings is not evident. Seven males and five females, exclusive of *triangulum* $\times$ *syspila* intergrades, have, respectively, 46 to 52 (average 49.6) caudals and 35 to 46 (average 40.3) dorsal body blotches; 42 to 46 (average 44.6) caudals and 33 to 43 (average 38.6) body blotches.

Juveniles of *triangulum* are more brightly colored than adults; they possess black-margined red, rather than brown, dorsal and

lateral spots. There is some indication of a proportionately shorter tail in hatchlings.

Geographic variation is summarized in table 64. Eastern milk snakes from the northernmost Illinois counties are phenotypically *triangulum*. Yet in the sample from northwestern Illinois some slight influence of *syspila* is suggested by the number of tail rings, by the lateral rows of spots, and by the size of dorsal blotches.

Intergradation of *triangulum* and *syspila* in western Illinois occurs at least as far south as Pike County, one specimen from near Pearl being approximately intermediate but closer to *syspila*. Specimens from Hamilton and Adams counties are unassignably intermediate. Intergradation in eastern Illinois apparently occurs in a narrower zone. Material from Tazewell and De Witt counties is closer to *triangulum*; Champaign and Vermilion county specimens are almost

Table 64.—Geographic variation in Illinois *Lampropeltis triangulum triangulum* and *L. t. triangulum* $\times$ *sysspila* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHEASTERN ILLINOIS (8)		NORTHWESTERN ILLINOIS (4)		WEST-CENTRAL ILLINOIS (4)		EAST-CENTRAL ILLINOIS (9)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals.....	202-215	209.3	201-209	204.0	205-213	208.7	198-213	204.8
Caudals.....	45-52	48.5	42-46	44.0	45-48	46.7	36-52	47.5
Tail length as percentage of total length.....	12.9-15.1	13.9	11.7-12.6	12.2	12.5-13.1	12.8	12.4-15.1	13.4
Rows of lateral spots.....	2	.....	1 $\frac{2}{3}$ -2	.....	1	.....	0-1 $\frac{2}{3}$	.....
Scale row contacting dorsal blotch at mid-body.....	2-6	4.1	2-5	3.4	1-2	1.7	0-4	2.0
Body blotches.....	35-46	39.1	33-43	39.0	21-33*	26.9	25-38	29.8
Tail rings.....	9-12	10.2	8-10	8.7	6-9*	7.3	7-11	8.2

*Counts based on 10 rather than 4 specimens.

exactly intermediate; a series from Coles County shows more *sysspila* influence. Most intergrades from areas where the *sysspila* influence predominates look like *sysspila* because of their red color, but they exhibit intergradation in details of pattern.

Individual variation in the number of scale rows and in head squamation is apparently identical in *L. t. triangulum* and *sysspila*. Accordingly, these counts for 40 specimens of *triangulum*, *sysspila*, and the intergrades are combined and are presented here. Anterior scale rows are 21 in 95.0 per cent, 22 in 2.5 per cent, 23 in 2.5 per cent of specimens; scale rows at mid-body are 21 in 95 per cent, 23 in 5 per cent; posterior scale rows are 17 in 51.0 per cent, 18 in 5.5 per cent, 19 in 41.0 per cent, and 21 in 2.5 per cent; supralabials are 7 + 7 in 97 per cent, 7 + 8 in 3 per cent; infralabials are 8 + 9 in 14.5 per cent, 9 + 9 in 82.5 per cent, and 9 + 10 in 3.0 per cent.

An albino specimen (INHS 5409), a male bearing the label "Chicago Area," is 929 mm. in total length. This male is typical in scutellation but it is cream colored and has dark red eyes. Anteriorly the venter has an obscure checkered pattern; posteriorly it is immaculate. Traces of the dorsal pattern are discernible in the form of blotch margins. This specimen has approximately 35 body blotches and 10 tail rings.

Habits.—The eastern milk snake is apparently common in the Chicago area but distinctly uncommon over the rest of Illinois. It is most often found by raising logs, rocks, or debris. The scanty information available on habits of the species in Illinois is based largely on behavior of captives. Like other kingsnakes this rather small snake vibrates its tail when disturbed. The species is known to eat small mammals, lizards, and snakes.

Pope (1944b) recorded that 8 to 16 adherent eggs are laid in June and early July, but it is not certain that his observation was based on Illinois specimens.

Illinois Distribution.—The eastern milk snake is a forest species, although in Illinois it evidently is not strictly confined to wooded regions. *L. t. triangulum* occurs in the northern third of the state, extending south to about Iroquois and Whiteside counties, fig. 208. *L. t. triangulum* $\times$ *sysspila* intergrades occur from these localities southward to Clark and Greene counties.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: BUREAU COUNTY: Milo (Cope 1900); COOK COUNTY: Beverly Hills, Chicago Ridge, Edgebrook (Schmidt & Necker 1935); Glen-



Fig. 208.—Distribution of *Lampropeltis triangulum*. Vertical hatching indicates the presumed range of the subspecies *triangulum* in Illinois; horizontal hatching, the presumed range of the subspecies *sypila*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the species in the United States.

view (Necker 1939c); Kenilworth, Northbrook, Richton Park, Willow Springs (Schmidt & Necker 1935); DU PAGE COUNTY: Glen Ellyn, Hinsdale (Schmidt & Necker 1935); Naperville (Necker 1939c); KANE COUNTY: Elburn (Necker 1939c); KANKAKEE COUNTY: Rock Creek Park (Stille & Edgren 1948); KNOX COUNTY: Galesburg (H. Garman 1892); LAKE COUNTY: Deerfield, Grass Lake (Schmidt & Necker 1935); Waukegan (Necker 1939c); MCHENRY COUNTY: McHenry (Necker 1939c); MCLEAN COUNTY: Normal (H. Garman 1892); MENARD COUNTY: Athens (Blanchard 1921); PEORIA COUNTY: Peoria (H. Garman 1892); STARK COUNTY: Elmira (Yarrow 1882a);

STEPHENSON COUNTY: Freeport (H. Garman 1892); VERMILION COUNTY: Danville (Blanchard 1921); WILL COUNTY: Joliet (Schmidt & Necker 1935); Romeoville (Necker 1939c).

Lampropeltis triangulum sypila (Cope)
Red Milk Snake

Ophibolus doliatus sypilus Cope 1888:384 (type locality: Richland, Illinois; revised to Richland County, Illinois, by Blanchard 1921).

Osceola doliata sypila, Cope 1900:892.

Lampropeltis triangulum sypila, Blanchard 1921:179–87.

Lampropeltis doliata sypila, Wright & Wright 1952:585.

Ophibolus doliatus doliatus nec Linnaeus, Yarrow 1882a:89.

Ophibolus triangulum doliatus nec Linnaeus, H. Garman 1892:295–6.

Lampropeltis doliatus nec Linnaeus, Hurter 1911:184.

Ophibolus doliatus nec Linnaeus, Hurter 1893:255.

Osceola doliata doliata nec Linnaeus, Cope 1900:890.

Osceola doliata collaris, Cope 1893a:1069.

Osceola doliata clerica, Cope 1900:888.

Ophibolus doliatus clericus, Brown 1901:73.

Osceola elapsoidea nec Holbrook, Davis & Rice 1883a:29.

Ophibolus elapsoidea nec Holbrook, H. Garman 1892:299–300.

Lampropeltis elapsoidea elapsoidea nec Holbrook, Wright & Wright 1952:586.

Ophibolus doliatus coccineus nec Schlegel, Davis & Rice 1883a:29.

Lampropeltis doliatus coccineus nec Schlegel, Jordan 1888:197.

Diagnosis.—A subspecies (largest Illinois specimen 844 mm. in total length) of *Lampropeltis triangulum*, fig. 209, differing from *L. t. triangulum* in color and pattern: 19 to 26 crimson, black-edged dorsal blotches between head and anus; dorsal blotches extending ventrad on the sides to ventrals or at least to first or second scale rows; one or less than one complete row of lateral spots alternating with dorsal saddles; tail with 4 to 8 black-margined red rings; head pattern without a chevron-shaped mark, with a pair of supraocular light spots.

Variation.—Sexual variation in *L. t. sypila* parallels that in *L. t. triangulum*. Eight males have 45 to 50 (average 47.0) caudals and 19 to 26 (average 23.1) body blotches; six females have 42 to 49 (average 44.2) caudals and 21 to 26 (average 22.5) body blotches.

Juveniles and adults are alike in pattern.



Fig. 209.—An adult *Lampropeltis triangulum syspila* from Union County, Illinois. The groundcolor is light gray or white; the blotches are bright red, heavily margined with black.

No geographic variation within Illinois has been discerned for *syspila* except for intergradation with *triangulum*, which has been described under that subspecies.

Individual variation in a sample of 14 specimens of *syspila* is as follows: ventrals 197 to 213 (average 202.5), tail length 11.9 to 14.1 (average 13.0) per cent of total length. Variation in scale rows and head squamation has been summarized under *L. t. triangulum*. The dorsal blotches in 14 specimens at hand extend to the edges of the ventrals or onto the first or second scale row. Forty-three per cent of the specimens possess a complete row of lateral spots alternating with the dorsal saddles; the others possess an incomplete row. An extreme case of the latter pattern is found in a Jasper County specimen in which the lateral spots are on only the posterior third of the body.

Habits.—This brightly colored snake is similar in habits to the eastern milk snake. There is some evidence that it is at least partially nocturnal. Individuals have been found in rotten logs or under bark of stumps.

Feeding and reproductive habits are presumably similar to those of the eastern milk snake.

Illinois Distribution.—The red milk snake, one of the most colorful of the Illinois reptiles, occurs in wooded regions of southern Illinois north to the Shelbyville Moraine in the eastern part of the state and to Calhoun County in the western, fig. 208. More individuals have been collected under flat rocks on wooded or grassy hillsides of the Lower Mississippi Border division than elsewhere in the state, but even there *syspila* is quite uncommon.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: CALHOUN COUNTY: Hardin (Blanchard 1921); JACKSON COUNTY: Murphysboro (Ditmars 1945); PULASKI COUNTY: Grand Chain (Blanchard 1921); RICHLAND COUNTY: (Cope 1888); ST. CLAIR COUNTY: (Hurter 1893); WABASH COUNTY: Mount Carmel (Yarrow 1882a).



Fig. 210.—An adult *Cemophora doliata* from Calhoun County, Florida. The groundcolor is gray or white; the blotches are bright red, heavily margined with black. The venter is plain white. (Photo by Isabelle Hunt Conant.)

Cemophora Cope

One monotypic species of *Cemophora* is known in southeastern United States. The majority of American herpetologists now assign the name *C. coccinea* (Blumenbach) to this species. Other authors, however, regard the name *doliata* Linnaeus as applicable to the scarlet snake.

Cemophora doliata (Linnaeus) Scarlet Snake

Coluber doliatus Linnaeus 1766:379 (type locality: Carolina; revised to vicinity of Charleston, South Carolina, by Schmidt 1953).

Cemophora doliata doliata, Bennett 1953:164.

Diagnosis.—A small, moderately slender snake (less than 600 mm. in total length), fig. 210, with 19 rows of smooth scales; anal plate entire; rostral scale pointed and wart-like; loreal present; supralabials 6 + 6; infralabials 6 to 8 on each side; preoculars 1 + 1, postoculars usually 2 + 2; top of snout red; groundcolor above gray, white, or yellow, with broad, black-bordered red rings; venter immaculate white or yellowish white.

Variation.—Details of sexual and ontogenetic variation are unknown for the species in this part of its range.

A single male of this species (SIU 542) is known from Illinois. This specimen has 19 scale rows, 161 ventrals, 41 caudals, 6 + 6 supralabials, 6 + 7 infralabials, 1 + 1 preoculars, 1 + 2 postoculars, and 1–2 temporals on each side, 19 body blotches, 8 tail rings, and a total length of 448 mm.,

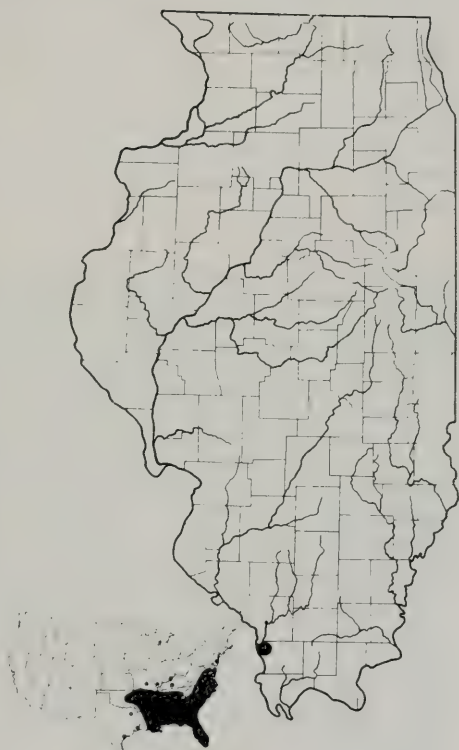


Fig. 211.—Distribution of *Cemophora doliata*. The lower map depicts the total known range of the species in the United States.

the tail comprising 14.7 per cent of the total length. The groundcolor dorsally is dark gray, the red saddles appearing lighter; the venter is unmarked.

Habits.—The scarlet snake presumably feeds on lizards, other snakes, and young mice. This small constrictor is fossorial and

apparently nocturnal. No information is available on the number or dimensions of the eggs in the northern part of the range of the species.

Illinois Distribution.—The sole Illinois specimen bears the label "Wolf Lake Swamp, Union Co., Illinois, July 26, 1942, F. R. Cagle." It was mistakenly cataloged as *Lampropeltis triangulum syspila*. Bennett (1953), at my suggestion, reported the error and recorded the genus for Illinois. Despite heavy collecting in the area, this specimen remains the only record for the state, fig. 211. There is growing doubt in the minds of herpetologists at Southern Illinois University that the specimen actually came from Wolf Lake. I am inclined to accept the record as valid, in view of similar circumstances in Indiana and Missouri, where many years elapsed before the initial records were substantiated by additional specimens, and in view of the failure of many hundreds of collectors over many decades to find *Tantilla gracilis* and *Natrix cyclopion* in the Wolf Lake area. *Cemophora* probably occurs on the slopes of Pine Hills rather than in the swamp.

Tantilla Baird & Girard

This New World genus contains, in the United States, nine species, some of which have several subspecies. One species is found in southwestern Illinois.

Tantilla gracilis hallowelli Cope Northern Flat-Headed Snake

Tantilla hallowelli Cope 1860a:77 (type locality: Manhattan, Kansas).

Tantilla gracilis hallowelli, Smith & Burger 1950:2.

Diagnosis.—A diminutive snake (largest Illinois specimen 203 mm. in total length), fig. 212, with 15 rows of smooth scales; flattened head, little wider than neck; frontal about four times the size of either supraocular; no loreal; preoculars 1 + 1, postoculars 1 + 1; supralabials usually 6 + 6; infralabials usually 6 + 6; eyes minute; anal plate divided; ventrals 121 to 132; caudals 42 to 51; color above tan or yellow-brown, with the top of the head darker, sometimes with a definite cap; venter salmon or orange

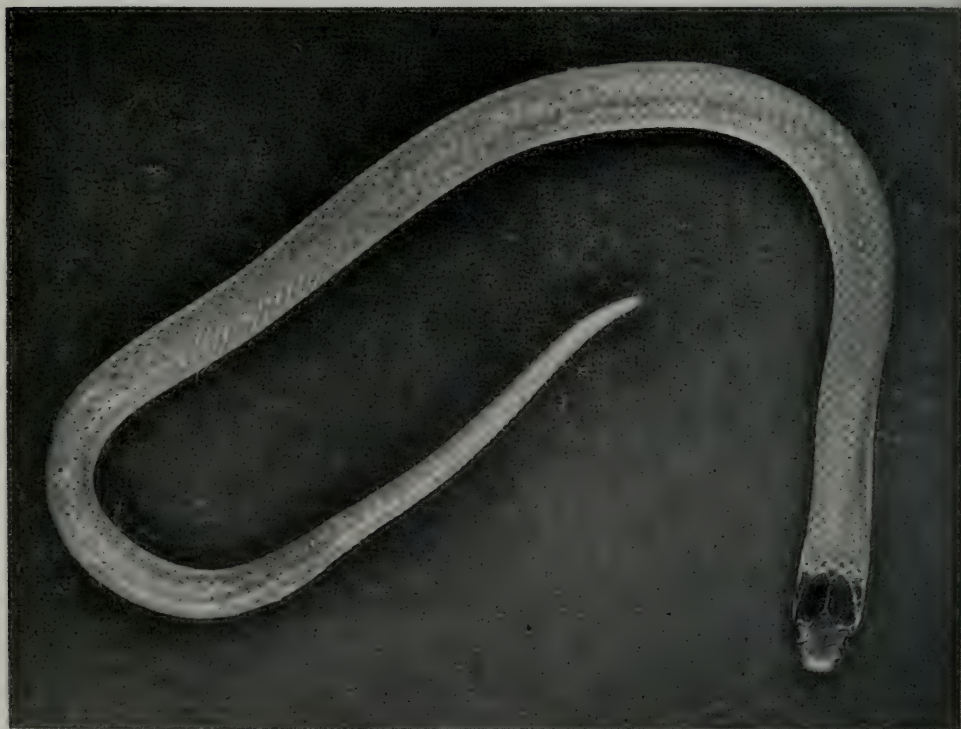


Fig. 212.—A subadult *Tantilla gracilis hallowelli* from Union County, Illinois. The color above is tan or light gray with a black cap on the head; below, salmon-pink.

medially, becoming white laterally and anteriorly.

Variation.—The male northern flat-headed snake has fewer ventrals, more caudals, and a proportionately longer tail than the female. The juvenile tends to have a darker and more conspicuous head cap than the adult.

Only 13 specimens of this snake have been found in Illinois. Eleven are available for study. Four males from Union County vary as follows: ventrals 121 to 124 (average 123), caudals 49 to 51 (average 49.7), tail length 21.1 to 23.7 (average 22.7) per cent of total length. Four females from the same locality have characters as follows: ventrals 125 to 132 (average 129.2), caudals 42 to 47 (average 43.7), tail length 18.4 to 20.4 (average 19.4) per cent of total length.

Three females from Monroe County vary as follows: ventrals 129 to 132 (average 130.6), caudals 44 to 45, tail length 17.9 to 20.2 (average 19.0) per cent of total length. Scale rows are 15 in all 11 snakes; supralabials are 5 + 6 in one, 6 + 6 in seven, 6 + 7 in two, 7 + 7 in one; infralabials are 6 + 6 in nine, 6 + 7 in one, and 6 + 5 in one; preoculars are 1 + 1 in nine, postoculars 1 + 1 in eight, 2 + 2 in one, and oculars undeterminable in two.

Habits.—The northern flat-headed snake, the smallest Illinois snake, is strictly fossorial. Specimens are usually found by raising flat rocks in dry talus slides. Although these tiny snakes possess minute poison glands and rear fangs, they are too small to bite man. Their food consists of small arthropods. I have not seen the eggs of the species.

Illinois Distribution.—The available specimens of this snake were found along the relatively arid Mississippi River bluffs in Monroe and Union counties, fig. 213. Neill (1951b) recalls having taken a snake of this species in St. Clair County, but it was not saved.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: ST. CLAIR COUNTY: near East St. Louis (Neill 1951b).

Thamnophis Fitzinger

Eleven species of *Thamnophis*, many with subspecies, are found in the United States and Canada. Other species occur in Mexico and Central America.

Thamnophis sauritus (Linnaeus)

Three subspecies of the ribbon snake are recognized in the United States. A western subspecies occurs in Illinois, presumably intergrading with the nominate form in the extreme southeastern part of the state, although there is some likelihood that the intergrade population has been recently exterminated.

Thamnophis sauritus proximus (Say) Western Ribbon Snake

Coluber proximus Say 1823:187 (type locality: stone quarry on west side of Missouri River,



Fig. 213.—Distribution of *Tantilla gracilis*. Hatching indicates the presumed range of the subspecies *hallowelli* in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

3 mi. above mouth of Boyer River, Pottawattamie County, Iowa).

Thamnophis sauritus proximus, Ruthven 1908b:43, 98-107.

Thamnophis proximus, Ditmars 1945:59.

Eutania proxima, Kennicott 1855:592.

Eutaenia proxima, Davis & Rice 1883a:30.

Eutania saurita proxima, H. Garman 1892:264-5.

Thamnophis proxima, McLain 1899:3.

Eutaenia faireyi, Cooper 1860:299.

Eutania saurita faireyi, H. Garman 1892:264-5.

Eutania faireyi, Hurter 1893:256.

Thamnophis proxima faireyi, Hurter 1911:160.

Eutania saurita, Yarrow 1882a:114.

Eutania saurita saurita nec Linnaeus, H. Garman 1892:264-5 (1).

Thamnophis sauritus sauritus nec Linnaeus, Van Cleave 1928:133, 136.

Thamnophis sauritus, Necker 1933:8.

Diagnosis.—A medium-sized, very slender snake (largest Illinois specimen 993 mm. in total length), fig. 214, usually with 19-19-17 rows of strongly keeled scales; ventrals 163 to 181; caudals 83 to 131; anal plate entire; supralabials usually 8 + 8; infralabials usually 10 + 10; preoculars usually 1 + 1, postoculars usually 3 + 3; tail length usually more than 25 per cent of total length; groundcolor usually jet black, with three distinct, longitudinal, light stripes; middorsal stripe orange; lateral stripes greenish white, involving third and fourth scale rows; a pair of prominent, light parietal spots nearly always present; venter, labials, and chin immaculate greenish white; a light bar on each preocular.

Variation.—The male of *Thamnophis sauritus proximus* is longer tailed than the female and has a slightly higher ventral count mean, table 65. Juveniles and adults are similar in color and pattern, but the young are more slender bodied.

The most striking geographic variation in *T. s. proximus* is found in the approach of southeastern Illinois specimens to *T. s. sauritus*. In fact, seven specimens from Richland and Wabash counties are perhaps referable to that race, inasmuch as they are more or less typical of eastern specimens in scutellation, table 66. All seven are very old and faded, and the colors are therefore not reliable. They appear to be intergrades, however, showing more brown and less distinct parietal spots than other Illinois specimens of comparable age. Ruthven (1908b) nevertheless assigned these same specimens to *proximus*, pointing out that they resembled

sauritus in several respects. No fresh material from eastern Illinois is available. When, and if, specimens turn up from this area, it will not be surprising if they are typical *T. s. sauritus* in color and pattern features. Specimens taken in the northern half of Illinois show little deviation in scale count averages from those taken in southwestern Illinois, table 66.

Individual variation in a sample of 40 specimens is as follows: scale rows 18-19-17 in 2.8 per cent of specimens, 19-17-17 in 8.5 per cent, 19-19-17 in 83.0 per cent, 20-19-17 in 5.7 per cent; infralabials 9 + 9 in 7.8 per cent, 9 + 10 in 5.2 per cent, 10 + 10 in 86.8 per cent; preoculars 1 + 1 in 100 per cent; postoculars 2 + 2 in 2.8 per cent, 2 + 3 in 2.8 per cent, 3 + 3 in 77.8 per cent, 3 + 4 in 13.8 per cent, and 4 + 4 in 2.8 per cent.

Habits.—This slender and brightly colored snake is quick in its movements. It climbs readily and swims rapidly. In the summer it is found around swamps and marsh edges and occasionally in upland woods. In the fall in southern Illinois the western ribbon snake occurs commonly at the bases of rock bluffs, where it apparently hibernates in rock crevices with rattlesnakes, copperheads, and black snakes. Newly captured individuals threaten with their mouths opened wide, but they rarely try to bite. Captives feed readily on frogs and small fish. On one occasion a large specimen ate two smaller ribbon snakes.

Data concerning the number of young produced by the female of this ovoviviparous species are meager in Illinois. One female had 12 young in early August. An intergrade *T. s. sauritus* × *proximus*, from adjacent Indiana, had 11 young on July 17.

Illinois Distribution.—The range of the western ribbon snake in Illinois is problematical, fig. 215. The species is fairly common along the Mississippi River bluffs and it is quite common in southwestern Illinois. Elsewhere in the state, it is extremely rare. No recent records are available for the central and eastern parts of Illinois, although such records are available for adjacent Indiana. This curious situation is not readily explained, for the scarcity of the species in the Shawnee Hills cannot be attributed to extensive cultivation of land or drainage.

Although undocumented by specimens, published records for the following localities



Fig. 214.—An adult *Thamnophis sauritus proximus* from Union County, Illinois. The groundcolor is black; the middorsal stripe, orange; the lateral stripes and venter are greenish white.

Table 65.—Sexual variation in Illinois *Thamnophis sauritus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (15)		FEMALES (22)	
	Range	Mean	Range	Mean
Ventrals.....	166–181	172.8	163–177	170.1
Caudals.....	108–131	115.9	83–114	100.7
Tail length as percentage of total length.....	29.2–33.6	31.0	24.0–31.9	28.3

Table 66.—Geographic variation in Illinois *Thamnophis sauritus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHWESTERN ILLINOIS (8)		SOUTHWESTERN ILLINOIS (22)		RICHLAND-WABASH COUNTIES (7)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	170–181	172.8	166–181	173.5	165–173	169.3
Female.....	165–172	169.3	163–177	174.4	165–167	166.0
Caudals						
Male.....	111–114	112.5	108–131	114.1	120–124	121.6
Female.....	83–103	93.0	9 –114	99.5	110–111	110.3
Tail length as percentage of total length						
Male.....	31.2–31.4	31.3	29.2–31.6	30.2	31.3–33.6	32.7
Female.....	24.7–29.1	27.1	24.0–30.0	27.8	31.0–31.9	31.3
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Supralabials						
7 + 7.....	12.5		9.1		42.8	
7 + 8.....	12.5		9.1		28.6	
8 + 8.....	75.0		81.8		28.6	



Fig. 215.—Distribution of *Thamnophis sauritus*. Vertical hatching indicates the presumed range of the subspecies *proximus* in Illinois; crosshatching, the area of intergradation between the subspecies *proximus* and *sauritus*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The species may no longer occur in the middle and eastern counties. The lower map depicts the total range of the species in the United States.

are believed valid and are indicated on the distribution map by hollow symbols: HANCOCK COUNTY: Dallas City (Ditmars 1907); JERSEY COUNTY: (H. Garman 1892); MADISON COUNTY: (Hurter 1911).

Thamnophis radix radix
(Baird & Girard)

Eastern Plains Garter Snake

Eutania radix Baird & Girard 1853:34 (type locality: Racine, Wisconsin); H. Garman 1892:266.

Eutania radix, Kennicott 1855:256.

Eutaenia radix, Hay 1881:738.

Tropidonotus radix, S. Garman 1884:23.

Tropidonotus ordinatus radix, Boulenger 1893:211.

Thamnophis radix, Ruthven 1903b:70–87.

Thamnophis radix radix, Van Cleave 1928:133, 136.

?*Eutaenia vagrans nec* Baird & Girard, Davis & Rice 1883a:30.

?*Eutaenia vagrans vagrans nec* Baird & Girard, Davis & Rice 1883b:39.

?*Eutania vagrans nec* Baird & Girard, H. Garman 1892:268.

?*Eutaenia butleri nec* Cope, Ditmars 1922:241.

?*Thamnophis butleri nec* Cope, Necker 1938:3.

?*Thamnophis radix butleri nec* Cope, Wright & Wright 1952:585.

?*Thamnophis*, Blaufuss 1943:56.

Diagnosis.—A medium-sized, moderately slender snake (largest Illinois specimen 756 mm. in total length), fig. 216, with 19 to 21 anterior and usually 17 posterior rows of strongly keeled scales; 143 to 165 ventrals; 59 to 82 caudals; anal plate entire; supralabials usually 7 + 7; infralabials 9 or 10 per side; 1 preocular and 3 postoculars per side; proportionate tail length usually less than



Fig. 216.—An adult *Thamnophis radix radix* from Champaign County, Illinois. The groundcolor is brown on which are superimposed black markings and three longitudinal stripes. The median stripe is dull orange; the others are yellowish gray.

25 per cent of total length; groundcolor brown, with three longitudinal light stripes; middorsal stripe orange-yellow and occupying one row of middorsal scales and half of each adjacent row in width; lateral stripes narrower, yellow-gray, and involving the third and fourth scale rows on each side; dark groundcolor on either side of middorsal stripe, with two rows of alternating black spots or squares; a pair of light occipital dots usually present; venter gray-green, with dark spots at least on edges of ventrals; labials barred with dark.

Variation.—Males of *Thamnophis radix radix* have higher ventral and caudal counts and proportionately longer tails than females, table 67. Juveniles and adults are similar in proportions and pattern.

Geographic variation in scutellation is rather slight within Illinois, but a reduced ventral count in the northeastern population is suggested, table 68.

The five specimens at hand from Madison County have a higher average number of scale rows than northern samples; the significance of this variation is unknown.

A trend toward melanism is found in the northeastern sample, many specimens having rather heavy black spots or streaks on the sides of the ventral scutes. Ventral spotting is less frequent in samples from western and southern Illinois. Specimens exhibiting a bright red-brown groundcolor occur occasionally in all parts of the state where the species occurs. May (1952) has described an albinistic specimen from the Chicago area.

Table 67.—Sexual variation in Illinois *Thamnophis radix radix*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (29)		FEMALES (32)	
	Range	Mean	Range	Mean
Ventrals.....	154-165	158.0	143-163	152.4
Caudals.....	68-82	74.8	59-70	65.3
Tail length as percentage of total length.....	20.8-25.5	24.0	19.3-23.7	21.2

Table 68.—Geographic variation in Illinois *Thamnophis radix radix*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EAST-CENTRAL ILLINOIS (12 MALES, 14 FEMALES)		MADISON COUNTY (1 MALE, 4 FEMALES)		NORTHEASTERN ILLINOIS (11 MALES, 13 FEMALES)		NORTHWESTERN ILLINOIS (6 MALES, 5 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals								
Male.....	154-165	159.0	154	.....	154-160	156.6	154-163	158.3
Female.....	149-160	154.6	149-156	152.5	143-163	150.3	149-154	151.8
Caudals								
Male.....	68-82	77.4	.....	.....	71-78	74.2	70-74	72.1
Female.....	60-70	65.8	67-71	68.6	59-69	64.2	65-68	66.7
Tail length as percentage of total length								
Male.....	23.7-25.5	24.4	.....	.....	22.6-25.4	23.9	20.8-24.8	23.7
Female.....	19.3-23.4	21.1	21.5-23.6	22.7	20.2-23.7	21.5	19.5-22.8	20.7

Other variation in *T. r. radix* shows no correlation with geography. In 61 specimens the anterior scale rows are 17 in 2 per cent of specimens, 19 in 80 per cent, 20 in 5 per cent, and 21 in 13 per cent; scale rows at mid-body are 19 in 74 per cent, 20 in 3 per cent, and 21 in 23 per cent; posterior scale rows are 15 in 8 per cent, 16 in 3 per cent, 17 in 87 per cent, and 18 in 2 per cent. Variation in head scutellation for these 61 snakes is as follows: supralabials 6 + 6 in 1 per cent, 6 + 7 in 1 per cent, 7 + 7 in 73 per cent, 7 + 8 in 22 per cent, 8 + 8 in 3 per cent; infralabials 8 + 8 in 2 per cent, 8 + 9 in 3 per cent, 9 + 9 in 22 per cent, 9 + 10 in 27 per cent, and 10 + 10 in 46 per cent; preoculars are 1 + 1 in 98 per cent, 1 + 2 in 2 per cent; postoculars 1 + 1 in 3 per cent, 2 + 2 in 3 per cent, 2 + 3 in 3 per cent, and 3 + 3 in 91 per cent. Light occipital dots are present on 87 per cent.

A specimen from Douglas County (INHS 3009) is anomalous, inasmuch as the lateral stripes encroach on the second scale rows as well as the third and fourth.

Habits.—The eastern plains garter snake is best known in vacant lots of cities and villages in the state. Comparatively few specimens have been found in remote areas. In the spring, this snake abounds in trashy areas and in meadows and pastures near villages. On wet or cool days, several individuals may congregate under a single object. Most individuals do not try to bite when captured, but they throw fecal matter that apparently consists largely of digested earthworms. Numerous specimens have been observed eating earthworms. These snakes may eat amphibians and other invertebrates also; captives have displayed no interest in insects.

Broods of 10, 10, 12, 13, 17, and 27 have been born in the laboratory, most of them in late August. A female killed at Volo on October 14 had 12 fully formed young still within her body.

Illinois Distribution.—The eastern plains garter snake is extremely abundant in certain muck prairie areas in the northern half of Illinois and it seems to thrive in the most heavily cultivated districts, fig. 217. The species has not been found in many Indiana counties bordering Illinois, probably because of the more forested aspect of these counties. The scarcity of records for west-central Illinois may be because the original



Fig. 217.—Distribution of *Thamnophis radix*. Hatching indicates the presumed range of the subspecies *radix* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

prairie areas in this part of the state, rolling and relatively well drained, lacked the extensive prairie marshes typical of much of the Grand Prairie. The southernmost recent record of this snake is from a prairie outlier in Cumberland County. Two old records for southern Illinois (Madison and Wabash counties) are based on USNM specimens collected in the last century. It is likely that the Madison County specimens were from a relict colony on a prairie outlier, a colony later exterminated. The Wabash County specimen was probably incorrectly cataloged, and the record is not accepted here.

Although undocumented by specimens, published records for the following localities are believed valid; most are shown on the distribution map by hollow symbols: COOK COUNTY: Argo (Schmidt & Necker 1935);

Arlington Heights (Necker 1939c); Berwyn (A. Smith 1949); Beverly Hills (Schmidt & Necker 1935); Blue Island (A. Smith 1949); Braeside, Chicago Lawn, Chicago Ridge (Schmidt & Necker 1935); Evanston (Necker 1939c); Flossmoor (A. Smith 1949); Forest Park, Homewood (Schmidt & Necker 1935); Kenilworth (A. Smith 1949); La Grange, Lambert (Necker 1939c); Longwood, Morgan Park, Palos Park (Schmidt & Necker 1935); Pullman (Necker 1939c); Riverdale, Summit (Schmidt & Necker 1935); Wheeling (Necker 1939c); Willow Springs, Winnetka, Wolf Lake (Schmidt & Necker 1935); DU PAGE COUNTY: Lombard, Naperville (Schmidt & Necker 1935); West Chicago, Wooddale (Necker 1939c); GRUNDY COUNTY: Diamond (A. Smith 1949); Pequot (Necker 1939c); HENRY COUNTY: Colona (H. Garman 1892); LAKE COUNTY: Barrington, Briggs Lake (A. Smith 1949); Deerfield, Fox Lake (Schmidt & Necker 1935); Highland Park (Necker 1939c); Waukegan (A. Smith 1949); McHENRY COUNTY: Richmond (Schmidt & Necker 1935); ROCK ISLAND COUNTY: Milan (H. Garman 1892); STEPHENSON COUNTY: Freeport (H. Garman 1892).

Thamnophis sirtalis (Linnaeus)

Eleven subspecies of *Thamnophis sirtalis* are recognized in the United States and Canada. The wide-ranging nominate subspecies and a subspecies restricted to the lower western and southern border of Lake Michigan occur in Illinois.

Thamnophis sirtalis sirtalis (Linnaeus) Eastern Garter Snake

Coluber sirtalis Linnaeus 1758:222 (type locality: Canada; revised to vicinity of Quebec by Klauber 1948).

Eutaenia sirtalis, Kennicott 1855:592 (part).

Eutaenia sirtalis, Schneck 1882:1008.

Eutaenia sirtalis sirtalis, Davis & Rice 1883a:30 (part).

Eutainia sirtalis, Hay 1891:110.

Eutainia sirtalis sirtalis, H. Garman 1892:266-7.

Thamnophis sirtalis sirtalis, Ruthven 1908b:176-86 (part).

Thamnophis sirtalis, Hurter 1911:163.

Eutaenia sirtalis parietalis nec Say, Cope 1875:41.

Eutainia sirtalis parietalis nec Say, H. Garman 1892:266-8.

Thamnophis sirtalis parietalis nec Say, Ruthven 1908a:392.

Thamnophis parietalis nec Say, Weed 1923:47.

Eutaenia sirtalis obscura, Yarrow 1882a:126.

Eutaenia sirtalis dorsalis nec Baird & Girard, Davis & Rice 1883a:30 (part).

Eutaenia vagrans nec Baird & Girard, Davis & Rice 1883a:30 (part).

Diagnosis.—A medium-sized, moderately slender snake (largest Illinois specimen 1,044 mm. in total length), fig. 218, usually with 19-19-17 rows of strongly keeled scales; ventrals 147 to 165; caudals 61 to 82; anal plate entire; supralabials usually 7 + 7; infralabials usually 10 + 10; usually 1 preocular and 3 postoculars per side; tail length usually less than 25 per cent of total length; groundcolor brown, red-brown, or dark blue-green, with black spots or squares between longitudinal light stripes; middorsal stripe gray or yellow, on median scale row and halves of adjacent rows; lateral stripes similarly colored involving second and third scale rows, noninterrupted; venter gray-green, with dark spots at edges of most of the ventrals; head usually without paired light parietal dots; labials with dark bars.

Variation.—The male of the eastern garter snake has a longer tail and a slightly higher caudal count average than the female, table 69.

Juvenile garter snakes are like the adults except that the baby snakes have proportionately larger heads. A few very large adults of *Thamnophis sirtalis* have tails that are proportionately shorter than those of juveniles, but the proportionate tail length averages in large series of adults and of juveniles are almost identical.

Geographic variation in scutellation of the eastern garter snake is remarkably slight in Illinois. The means for ventral and caudal counts and the proportionate tail lengths of approximately 40 snakes from eastern Illinois and a sample of similar size from the western side of the state vary no more than 1 per cent. Likewise, comparison of these scale counts for specimens from extreme southern and extreme northern Illinois reveals no geographic variation. The mean ventral and caudal counts are somewhat at variance with those from an Ohio sample (Conant 1938), but they are much closer to those from Ohio than to those of a Nebraska sample of *T. sirtalis parietalis* (Hudson 1942).

The red pigment in the groundcolor, an

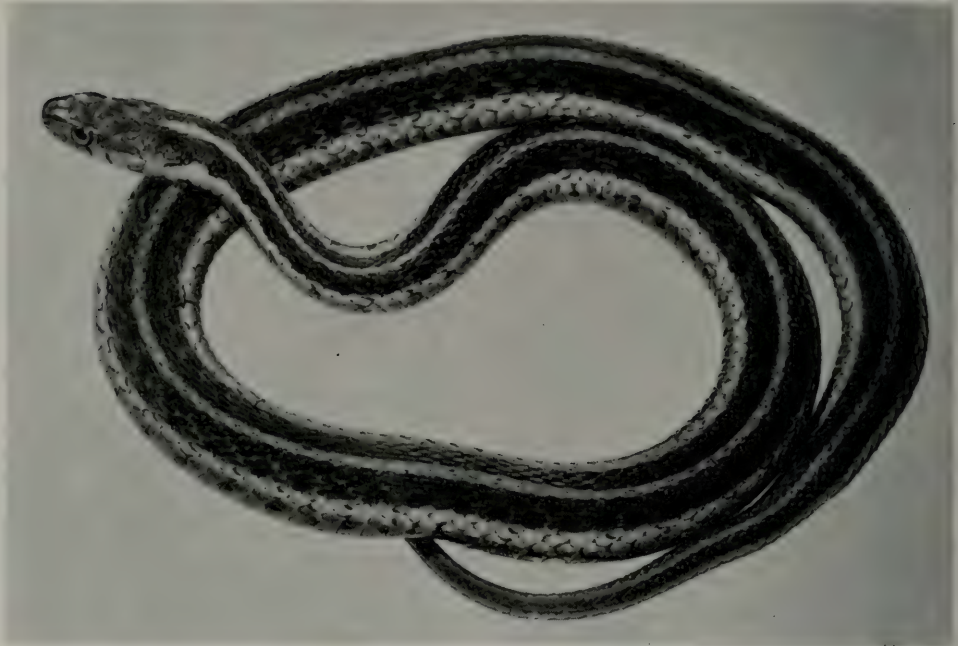


Fig. 218.—An adult *Thamnophis sirtalis sirtalis* from Douglas County, Illinois. The groundcolor is brown on which are superimposed black markings and three longitudinal tan stripes.

Table 69.—Sexual variation in Illinois *Thamnophis sirtalis*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (38)		FEMALES (54)	
	Range	Mean	Range	Mean
Ventrals.....	150-163	156.9	147-165	153.6
Caudals.....	70-82	76.3	61-74	67.0
Tail length as percentage of total length.....	22.8-26.0	24.2	18.0-24.4	21.7

alleged diagnostic character of *parietalis*, appears occasionally in populations of *T. sirtalis* throughout Illinois. Thirty-three per cent of a sample of 12 snakes from north-western Illinois, 42 per cent of a sample of 20 snakes from east-central Illinois, 55 per cent of a sample of 20 snakes from west-central Illinois, and 26 per cent of a sample of 20 snakes from extreme southern Illinois have some red on the sides of the body.

In view of the homogeneity of garter snakes in Illinois in scutellation and in color, there is no basis for including *T. s. parietalis* as a part of the Illinois fauna, the numerous reports of it and of *sirtalis* × *parietalis* intergrades in the western part of the state notwithstanding.

In pattern, however, there is pronounced geographic variation among garter snakes within Illinois. Toward the northeast the lateral stripes on the anterior part of the body tend to be interrupted at regular intervals by crossbars formed by the fusion of the black spots just above and just below the lateral line. The crossbarred pattern is sufficiently constant in garter snakes found along the southwestern border of Lake Michigan for the population to be recognized subspecifically as *semifasciata*. Intergradation between *sirtalis* and *semifasciata* is manifested by the increasing frequencies, toward the northeast, of specimens with the crossbarred pattern. The cline is steep from west to east, sloped from south to north.

Scutellation is apparently identical in the two Illinois subspecies of *T. sirtalis*. Individual variation in 91 specimens of both races is as follows: anterior scale rows are 19 in 95.5 per cent, 20 in 4.5 per cent; scale rows at mid-body are 18 in 5.5 per cent, 19 in 93.5 per cent, 20 in 1.0 per cent; posterior scale rows are 16 in 2 per cent, 17 in 98 per cent; supralabials are 6 + 6 in 1 per cent, 6 + 7 in 3 per cent, 7 + 7 in 89 per cent, 7 + 8 in 6 per cent, 8 + 9 in 1 per cent; infralabials are 8 + 8 in 3 per cent, 9 + 9 in 7 per cent, 9 + 10 in 11 per cent, 10 + 10 in 73 per cent, 11 + 11 in 3 per cent, 8 + 10 in 3 per cent; preoculars are 1 + 1 in 100 per cent; postoculars are 2 + 3 in 2 per cent, 3 + 3 in 95 per cent, 3 + 4 in 1 per cent, 2 + 4 in 1 per cent, and 4 + 4 in 1 per cent.



Fig. 219.—Distribution of *Thamnophis sirtalis*. Vertical hatching indicates the presumed range of the subspecies *sirtalis* in Illinois; horizontal hatching, the presumed range of the subspecies *semifasciata*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of the species in the United States.

Habits.—The eastern garter snake, although occasionally found in shrubbery and in water, is essentially terrestrial. It occurs in a variety of places but seems to prefer a forest-edge habitat. Most individuals of *T. sirtalis* bite and void excrement when captured. This species feeds on a variety of animals including frogs, toads, salamanders, earthworms, fish, young birds, and leeches.

The number of young per brood varies considerably. A captive female gave birth to 27 young in the laboratory in September. Cagle (1942a) recorded a litter of 53 born in early July.

Illinois Distribution.—*T. s. sirtalis* is generally distributed throughout Illinois except in the northeastern fourth of the state, where it is replaced by *semifasciata*, fig. 219. It is relatively uncommon in many parts of central Illinois.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: KNOX COUNTY: 2½ mi. E Galesburg (Adcock 1922); MADISON COUNTY: (Hurter 1911); MONROE COUNTY: 3 mi. N Red Bud (Blanchard 1924b); PEORIA COUNTY: Peoria (H. Garman 1892); ST. CLAIR COUNTY: Belleville (Yarrow 1882a).

Thamnophis sirtalis semifasciata (Cope) Chicago Garter Snake

Eutaenia sirtalis semifasciata Cope 1892:692–3
(type locality: Des Plaines, Illinois, and Wisconsin).

Thamnophis sirtalis semifasciata, P. W. Smith 1956a:81–4.

Eutaenia sirtalis nec Linnaeus, Kennicott 1855: 592 (part).

Eutaenia sirtalis sirtalis nec Linnaeus, Yarrow 1882a:123–4.

Eutaenia sirtalis nec Linnaeus, Gastman 1884: 89 (1).

Thamnophis sirtalis sirtalis nec Linnaeus, Ruthven 1908b:176–86 (part).

Thamnophis sirtalis nec Linnaeus, Weed 1923: 46.

Eutaenia sirtalis parietalis nec Say, Davis & Rice 1883b:40 (part).

Thamnophis sirtalis parietalis nec Say, Weed 1922:85.

Thamnophis parietalis nec Say, Weed 1923:47 (part).

Eutaenia sirtalis obscura, Davis & Rice 1883a: 30.

Eutaenia sirtalis dorsalis nec Baird & Girard, Davis & Rice 1883a:30.

Eutaenia vagrans vagrans nec Baird & Girard, Davis & Rice 1883a:30.

Eutaenia vagrans nec Baird & Girard, Davis & Rice 1883b:39 (part).
Eutainia vagrans nec Baird & Girard, H. Garman 1892:268.
Thamnophis, Blaufuss 1943:56.
Thamnophis ordinatus, Mertens 1951:13.

Diagnosis.—A medium-sized snake, a subspecies (largest Illinois specimen 905 mm.) of *Thamnophis sirtalis*, differing from *T. s. sirtalis* only in markings; lateral stripes on anterior part of body interrupted at regular intervals by black crossbars, which are formed by fusion of the black spots just above and just below the lateral stripe on each side of body, fig. 220.

Variation.—Sexual and ontogenetic variation are apparently identical in *T. s. sirtalis* and *semifasciata* and are described in the account of *T. s. sirtalis*.
Geographic variation in the Chicago garter snake consists of a clinal reduction toward the west and south in the frequency of snakes with black crossbars. In northwestern Illinois the area in which typical *sirtalis* replaces typical *semifasciata* is probably no more than 40 miles in width. In central Illinois the area of intergradation is as much as 100 miles wide. Crossbars in 118 specimens of *semifasciata* and 45 intergrades have been arbitrarily classified in table 70

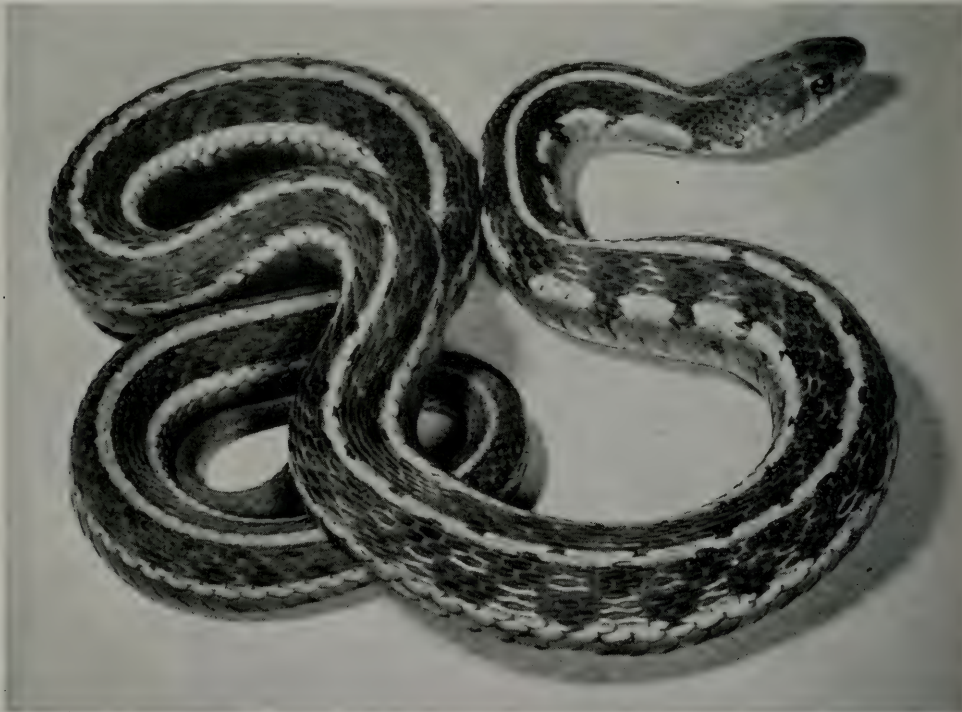


Fig. 220.—An adult *Thamnophis sirtalis semifasciata* from Lake County, Illinois. The groundcolor is brown on which are superimposed black markings and three longitudinal tan stripes.

Table 70.—Geographic variation in crossbarred pattern in Illinois *Thamnophis sirtalis semifasciata* and *T. s. sirtalis* × *semifasciata* intergrades, expressed in per cent. Figures in parentheses are numbers of specimens.

CROSSBARRED PATTERN	<i>T. s. semifasciata</i> (118)	<i>T. s. sirtalis</i> × <i>semifasciata</i> (45)
Prominent.....	59	22
Weak.....	37	40
Absent.....	4	38

as "Prominent" if more than three crossbars interrupt the lateral stripe on each side of the body and if the crossbars are readily discernible, "Weak" if only one to three crossbars interrupt each lateral stripe or if all the crossbars are dim, and "Absent" if the lateral stripes are not interrupted at all.

Individual variation for *semifasciata* in scutellation and in color apparently parallels that described under *sirtalis*.

Habits.—The remarks concerning the habits of *T. s. sirtalis* apply equally well to those of *semifasciata*. Pope (1944*b*) records the range in litter size of 12 to 42; and, although the provenance of his specimens is not stated, his counts presumably were made on Chicago area snakes.

Illinois Distribution.—The Chicago garter snake occurs in typical form from Lake Michigan south to Kankakee and La Salle counties and west to Lee and Winnebago counties, fig. 219. Intergradation with the nominate race occurs from these localities south to Iroquois and Peoria counties and west almost to the Mississippi River.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Aux Plaines (Ruthven 1908*b*); Berwyn, Beverly (Schmidt & Necker 1935); Deer Grove (Necker 1939*c*); Evanston (Schmidt & Necker 1935); Glenview (Necker 1939*c*); Lemont, Morgan Park, Niles Center, Northbrook (Schmidt & Necker 1935); Northfield (Yarrow 1882*a*); Palatine, Palos Park, Summit (Schmidt & Necker 1935); DU PAGE COUNTY: Naperville (Schmidt & Necker 1935); KANE COUNTY: Batavia (Stille & Edgren 1948); LAKE COUNTY: Beach (Schmidt & Necker 1935); Dead River (Necker 1939*c*); Fox River Grove, Highland Park, Pistakee Lake (Schmidt & Necker 1935); Sayer Bog (Necker 1939*c*); McHENRY COUNTY: Richmond, Woodstock (Schmidt & Necker 1935).

Tropidoclonion Cope

A single species with three subspecies is placed in this genus. The few Illinois specimens extant are tentatively assigned to the nominate race, in accordance with a recent study by Ramsey (1953). The material from Illinois is at variance with the descrip-

tion of the subspecies *lineatum*, particularly in caudal and ventral counts; but our series is not large enough to ascertain the significance of the differences in these characters. An adequate sample of Illinois specimens is extant in a personal collection but has not been available to me for scale counts.

Tropidoclonion lineatum lineatum

(Hallowell)

Northern Lined Snake

Microps lineatus Hallowell 1857:241 (type locality: Kansas; revised to Kansas City by Schmidt 1953; revised to Fort Leavenworth by Ramsey 1953).

Tropidoclonion lineatum, Jordan 1888:361.

Tropidoclonion lineatum, Stejneger 1892:504.

Tropidoclonio lineatum, Wright & Wright 1952:585.

Tropidoclonion lineatum lineatum, Ramsey 1953:11, 21, 22.

Tropidoclonium lineata, H. Garman 1890:187-8.

Diagnosis.—A small, moderately slender, burrowing snake (largest Illinois specimen 314 mm. in total length), fig. 221, with 15 to 17 anterior, 17 to 19 mid-body, and 16 to 17 posterior rows of strongly keeled scales; ventrals 135 to 150; caudals 26 to 47; anal plate usually entire; supralabials 5 to 7 per side; infralabials 6 or 7 per side; preoculars 1 + 1 and postoculars 2 + 2; tail length less than 20 per cent of total length; ground-color brown above, with three longitudinal gray stripes; middorsal stripe occupying median and adjacent halves of scale rows; lateral stripe involving second scale row anteriorly, second and third posteriorly; each longitudinal stripe bordered by single series of minute black dots; venter gray or white, with a double series of black half-moon-shaped markings from chin to tip of tail.

Variation.—Eight of the 10 specimens of the lined snake at hand are females; the scale counts given by Garman (1890) for three Champaign County specimens presumably refer to females, although he did not indicate the sex of his specimens. Ramsey (1953) stated that males have an average caudal count of about 8 scales more than females and that the proportionate tail length mean is greater in males by about 4 per cent.

Juveniles are much like adults, but their striped dorsal pattern is perhaps more evident. The black dots bordering the longitudinal stripes are somewhat more conspicuous in young snakes than in adults.

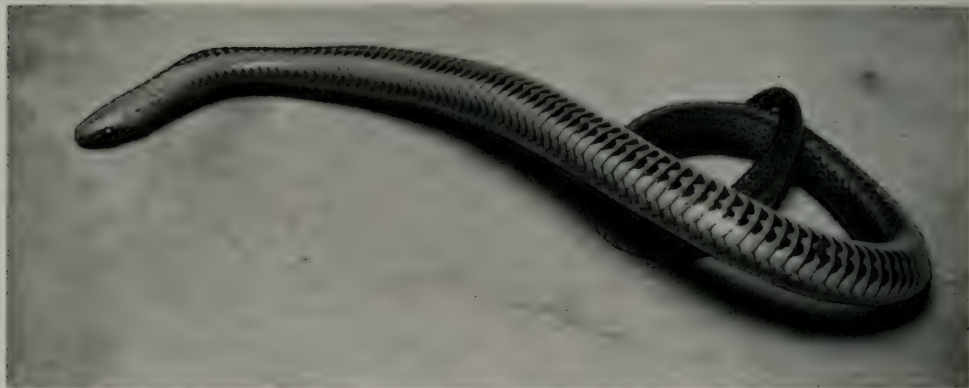


Fig. 221.—A subadult *Tropidoclonion lineatum lineatum* from Sangamon County, Illinois. The groundcolor above is brown with three varying distinct, longitudinal gray stripes; below, white with paired black spots.

A summary of the variation for the eight females examined and for Garman's counts is as follows: the number of ventrals 138 to 150 (average 145.2); caudals ?26 to 38 (average ?32.7); supralabials 5 + 5 in 36 per cent of specimens, 6 + 6 in 46 per cent, 6 + 7 in 18 per cent; infralabials 6 + 6 in 88 per cent, 7 + 7 in 12 per cent; preoculars 1 + 1 in 100 per cent, postoculars 2 + 2 in 100 per cent; anterior scale rows 17 in 50 per cent, 16 in 38 per cent, 15 in 12 per cent; scale rows at mid-body 17 in 27 per cent, 18 in 18 per cent, 19 in 55 per cent; posterior scale rows 16 in 25 per cent, 17 in 75 per cent; tail length 11.6 to 15.3 (average 13.1) per cent of total length. One specimen has a divided anal plate. Data for the two males are as follows: ventrals 144 and 145; caudals 40 and 46; supralabials and infralabials 6 + 6; preoculars 1 + 1; postoculars 2 + 2; scale row formula 17-18-16 and 17-19-17; and tail length 16.4 and 16.5 per cent of total length.

The scale counts of the Illinois series agree more closely with those of *Tropidoclonion lineatum annectans*, the race occurring in the Great Plains from north Texas to central Kansas, than with those of the nominate subspecies, which occurs in Nebraska and adjacent parts of Kansas, South Dakota, Iowa, and Missouri. When more specimens are available from Illinois, Iowa, and Missouri, it may be necessary to revise the distributional relationships of the subspecies *lineatum* and *annectans*.

Habits.—The lined snake has the appearance of a diminutive garter snake. It has semifossorial habits; all the specimens

available have been found under rocks, logs, or trash. Captured individuals are completely passive. Earthworms are their chief food.

Little is known of the reproductive habits of this snake in Illinois. Farther west, however, the seven or eight young per brood are born in August or September.

Illinois Distribution.—The rare lined snake apparently occurs in central Illinois in a few scattered colonies, most of which are probably vacant lot populations within cities, fig. 222. The present distribution of this species east of the Mississippi River is believed to consist of relicts of the Xerothermic Period. The range of *Tropidoclonion* was probably reduced to scattered small colonies before Illinois was settled; cultivation and related practices in all likelihood have aided the climatic shifts in reducing the number of populations except those which by accident had cities grow up about them.

Not included with the records plotted on the accompanying map is a report of a specimen seen at Moline. Richard B. Loomis of Long Beach, California, informed me by letter that he captured a lined snake at Moline, Rock Island County, in 1942 but that this snake escaped before it could be preserved.

Attempts to find recent specimens of this snake in vacant lots of Urbana have been fruitless. The colony reported there by Garman (1890) has probably been destroyed.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: CHAM-



Fig. 222.—Distribution of *Tropidoclonion lineatum*. Solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total known range of the species in the United States.

PAIGN COUNTY: Urbana (H. Garman 1890).

Virginia Baird & Girard

This North American genus comprises a monotypic and a polytypic species. A western subspecies of the latter occurs in Illinois. Until recently the generic name *Haldea* was applied to these species.

Virginia valeriae elegans Kennicott Western Earth Snake

Virginia elegans Kennicott 1859:99 (type locality: timbered regions of southern Illinois).

Virginia harpetii elegans, Bocourt 1886:32, figs. 4, 4a.

Virginia valeriae elegans, Blanchard 1923a: 351-6.

Haldea valeriae elegans, Stejneger & Barbour 1939:132.

Virginia valeriae, Cope 1875:35.

Haldea valeriae, Murrill 1945:23.

Haldea valeriae valeriae nec Baird & Girard, Wright & Wright 1952:586.

Haldea striatula nec Linnaeus, Cope 1877:64.

Potamophis striatulus nec Linnaeus, Van Cleave 1928:133, 136.

Diagnosis.—A small, moderately stout-bodied snake (largest Illinois specimen 300 mm. in total length), fig. 223, with 17 rows of faintly keeled scales; ventrals 118 to 132; caudals 31 to 46; anal plate divided; supralabials 6 + 6; infralabials 5 to 7 on a side; tail length less than 22 per cent of total



Fig. 223.—A juvenile *Virginia valeriae elegans* from Union County, Illinois. The color above is brown; below, greenish white. The specimen pictured here is proportionately large headed because it is a juvenile.

Table 71.—Sexual variation in Illinois *Virginia valeriae elegans*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (10)		FEMALES (12)	
	Range	Mean	Range	Mean
Ventrals.....	118-127	121.5	124-132	127.7
Caudals.....	38-46	43.3	31-38	34.9
Tail length as percentage of total length.....	18.6-21.4	20.2	15.1-18.5	16.3

Table 72.—Geographic variation in Illinois *Virginia valeriae elegans*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	SHAWNEE HILLS (11)		SOUTHERN ILLINOIS NORTH OF SHAWNEE HILLS (11)	
	Range	Mean	Range	Mean
Ventrals.....				
Male.....	118-123	120.4	119-127	122.6
Female.....	125-132	128.5	124-131	127.0
Caudals.....				
Male.....	38-46	41.8	44-46	44.8
Female.....	31-38	34.3	35-36	35.5
Tail length as percentage of total length.....				
Male.....	18.6-21.2	19.8	20.4-21.4	20.7
Female.....	15.1-17.8	16.0	15.6-18.5	16.6

length; head thick; nose rather sharply pointed; dorsum olive, medium brown, or gray-brown, sometimes with minute dark flecks; venter white, sometimes with a few dark flecks on sides of the ventrals.

Variation.—In this species the males have a lower average number of ventrals than the females but higher caudal counts and proportionately longer tails, table 71. The juveniles have proportionately larger heads than the adults.

The material available lends itself to being placed in three groups, one from the Wabash Border region, one from extreme southern Illinois, and one from the Lower Mississippi Border. Means of ventral and caudal counts for the eastern and western samples are almost identical, and they have accordingly been lumped in order to compare them with those for the extreme southern Illinois sample, table 72. This comparison reveals a general trend toward higher average ventral and caudal counts and longer tails in the more northern sample. The northern sample is at the periphery of the range of this species.

Individual variation in other features of scutellation for 22 snakes is as follows: scale rows 17 in 91.0 per cent of specimens, 15-17 in 4.5 per cent, 17-16-17 in 4.5 per cent; supralabials 6 + 6 in 100 per cent; infra-labials 5 + 5 in 4.5 per cent, 5 + 6 in 4.5 per cent, 6 + 6 in 77.0 per cent, 6 + 7 in 14.0 per cent; preoculars absent in 91 per cent, a tiny preocular present on at least one side of the head in 9 per cent; postoculars 1 + 1 in 4 per cent, 1 + 2 in 4 per cent, 1 + 3 in 4 per cent, 2 + 2 in 46 per cent, 2 + 3 in 32 per cent, and 3 + 3 in 9 per cent. One specimen has partially fused internasals; the other 21 specimens have divided internasals.

The dorsal color varies from medium brown to light brown; the venter is white, usually with a slight greenish yellow tint but sometimes with a flesh-color tint. Many specimens have minute dark flecks on the dorsum and small brown dots on the edges of the ventral plates. Occasionally an individual is found that has a faint, middorsal light band.

Habits.—This small snake is semifossorial in habits, and it is usually found under

rocks on wooded hillsides. It has been found abroad at night on several occasions. The most productive collecting sites have proved to be ditches or other excavations into which these reptiles have fallen. Several specimens have been raked up with forest-floor litter in material for Berlese samples. The food of this snake probably consists of soft-bodied arthropods and earthworms.

Broods of five tiny young have been born in the laboratory on two occasions, both in mid-August.

Illinois Distribution.—The western earth snake is evidently generally distributed south of the Shelbyville Moraine, fig. 224. The label of a specimen, USNM 7303, "Cook County, Illinois," almost certainly represents an error in cataloging, and the record has been rejected by most authors.



Fig. 224.—Distribution of *Virginia valeriae*. Hatching indicates the presumed range of the subspecies *elegans* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Virginia valeriae elegans is probably more common in the southern third of Illinois than the records indicate, but specimens are difficult to collect because of their preference for forest-floor debris, their small size, and their nocturnal habits.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Elkhart (Cagle 1942a); ST. CLAIR COUNTY: Bluff Lake (Hurter 1893).

Storeria Baird & Girard

Two polytypic species of this North American genus occur in the United States. Both are found in Illinois.

Storeria dekayi wrightorum Trapido
Midland Brown Snake De Kay's Snake

Storeria dekayi wrightorum Trapido 1944:57
(type locality: Reelfoot Lake, Tennessee).

Storeria dekayi wrightorum, Langebartel 1947:27-8.

Storeria dekayi, Kennicott 1855:592.

Ischnognathus dekayi, Boulenger 1893:287.

Storeria De Kayi, Hurter 1893:257.

Diagnosis.—A small, moderately stout-bodied snake (largest Illinois specimen 425 mm. in total length), fig. 225, with 17 rows of strongly keeled scales; ventrals 122 to 142; caudals 43 to 59; anal plate divided; tail length 17 to 26 per cent of total length; supralabials usually 7 + 7; infralabials usually 7 + 7; preoculars usually 1 + 1; postoculars usually 2 + 2; groundcolor gray or light brown, usually with a dim middorsal light stripe; middorsal stripe with numerous narrow dark crossbars, giving the middle of the back a ladder-like appearance, or middorsal stripe with a series of small dark spots or transverse dashes bordering either side; a more prominent dark blotch on either side of neck just behind the head and a dark spot below each eye; venter pinkish white and unmarked except for fine stippling on the sides of the ventrals.

Variation.—Males of the midland brown snake have fewer ventrals but more caudals and longer tails than females, table 73. Juveniles differ from adults and subadults in the possession of a white or light gray collar just behind the head. This collar, sometimes retained in the subadult, is distinctive and suggests a different species.



Fig. 225.—An adult *Storeria dekayi wrightorum* from Douglas County, Illinois. The groundcolor is light brown; the spots are dark brown or black.

Table 73.—Sexual variation in Illinois *Storeria dekayi wrightorum*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (22)		FEMALES (35)	
	Range	Mean	Range	Mean
Ventrals.....	122-131	126.5	127-142	133.9
Caudals.....	50-59	55.0	43-54	49.0
Tail length as percentage of total length.....	20.2-25.6	23.7	17.7-23.2	20.4

Geographic variation in *Storeria dekayi* within Illinois, as indicated by four samples (extreme northern, eastern, western, and southern Illinois) is not pronounced, but a southward trend toward a reduction in the number of ventrals in males is suggested. This situation can be expressed as an increasing degree of sexual dimorphism in ventral counts toward the south, table 74. The frequency of specimens with dark crossbars on the dorsum, one of the alleged diagnostic characters of *S. d. wrightorum*, appears to vary geographically. The samples available suggest that the crossbarred condition occurs rarely in northeastern Illinois samples and in approximately two-thirds of the snakes from eastern Illinois, but it

is usually present on western and southern Illinois examples.

Other variation in a sample of 56 snakes is as follows: scale rows 17 in 100 per cent; supralabials 7 + 7 in 94 per cent, 7 + 6 in 2 per cent, 7 + 8 in 2 per cent, 6 + 6 in 2 per cent; infralabials 7 + 7 in 90 per cent, 7 + 8 in 4 per cent, 7 + 6 in 2 per cent, 6 + 6 in 4 per cent; preoculars 1 + 1 in 98 per cent, 2 + 1 in 2 per cent; postoculars 2 + 2 in 85 per cent, 2 + 3 in 8 per cent, 2 + 1 in 6 per cent, 3 + 3 in 1 per cent.

Despite the low frequency of eastern specimens with typical *wrightorum* dorsal patterns, table 74, these snakes are nevertheless referable to *wrightorum* on the basis of the sums of ventral and caudal counts and the

Table 74.—Geographic variation in Illinois *Storeria dekayi wrightorum*.

CHARACTERISTIC	NORTHEASTERN ILLINOIS*		EAST-CENTRAL ILLINOIS*		WEST-CENTRAL ILLINOIS*		SOUTHWESTERN ILLINOIS*	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ventrals								
Male.....	126-130	128.4	125-131	126.8	124-130	126.8	122-125	124.0
Female.....	131-136	132.6	128-141	133.7	130-142	134.8	129-141	133.6
Difference.....	4-6	4.2	3-10	6.9	6-12	7.9	7-16	10.0
Caudals								
Male.....	53-57	54.6	51-58	55.1	50-58	54.6	53-59	55.7
Female.....	47-50	48.3	43-54	48.5	45-53	49.0	43-52	47.6
Sum of ventrals and caudals.....	178-186	182.2	174-193	181.9	175-195	183.3	177-187	181.0
	PER CENT OF SPECIMENS†		PER CENT OF SPECIMENS†		PER CENT OF SPECIMENS†		PER CENT OF SPECIMENS†	
Dorsal pattern crossbarred.....	0		66		79		90	
Dark bar on anterior temporal.....	89		100		93		84	

*Data based on 5 males and 3 females in northeastern Illinois, 6 males and 12 females in east-central Illinois, 7 males and 10 females in west-central Illinois, and 4 males and 9 females in southwestern Illinois.

†Data based on 9 specimens in northeastern Illinois, 29 specimens in east-central Illinois, 19 specimens in west-central Illinois, and 39 specimens in southwestern Illinois.

high percentage of specimens with dark bars on the anterior temporals.

An albinistic subadult was captured in Charleston, Coles County, in 1942. This specimen, which was not preserved, was cream colored and had pink dorsal spots.

Habits.—This small snake occurs in forest and prairie habitats and on both floodplains and uplands. It has been found most frequently under debris in urban vacant lots and in forest-edge habitats, such as partially wooded pastures and parklike groves. An unusual concentration of several dozen snakes was found along the highway near Fountain Bluff, Jackson County, in October of 1952. These snakes had evidently congregated along the highway shoulder to hibernate, and they had probably moved into this site from adjacent cultivated fields on the Mississippi River floodplain. *S. dekayi* feeds primarily on earthworms. Pope (1944b) recorded that it eats newly transformed toads.

Captive females from central Illinois have given birth to broods of 5, 6, 12, 23, and 17 young in late July or August. Cagle (1942a) reported a southern Illinois specimen had 8 young in early August, and Pope (1944b) recorded a brood of 24 young born August 1 to a female from Cook County.

Illinois Distribution.—De Kay's snake is abundant in all parts of Illinois, fig. 226. The difficulty in obtaining specimens by conventional collecting techniques accounts for the gaps on the accompanying map.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Aux Plaines (Yarrow 1882a); Berwyn, Beverly Hills (Schmidt & Necker 1935); Braeside, Edgebrook, Elmwood Park, Homewood, Lambert (Necker 1939c); Longwood, Pullman, Riverdale, Summit, Willow Springs (Schmidt & Necker 1935); Englewood (H. Garman 1892);



Fig. 226.—Distribution of *Storeria dekayi*. The subspecies *wrightorum* occurs throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

DU PAGE COUNTY: Downers Grove, Ingaltton (Schmidt & Necker 1935); Naperville (Necker 1939c); KANE COUNTY: Batavia, West Dundee (Stille & Edgren 1948); LAKE COUNTY: Pistakee Lake (Schmidt & Necker 1935); Sayer Bog (Necker 1939c); PEORIA COUNTY: Peoria (H. Garman 1892); WILL COUNTY: New Lenox (Schmidt & Necker 1935); WOODFORD COUNTY: Kappa (H. Garman 1892).

Storeria occipitomaculata
occipitomaculata (Storer)
Northern Red-Bellied Snake

Coluber occipito-maculatus Storer 1839:230
(type locality: Amherst, Massachusetts).

Storeria occipito maculata, Kennicott 1855:592.

Storeria occipitomaculata, Yarrow 1882a:129.

Storeria occipitomaculata occipitomaculata,
Pope 1944b:201-4.

Storeria occipito-maculata, Weed 1922:87.

Storeria occipito-maculata occipito-maculata,
Trapido 1944:20-33.

Diagnosis.—A small, moderately slender snake (largest Illinois specimen 311 mm. in total length), fig. 227, with 15 rows of strongly keeled scales; ventrals 117 to 130; caudals 41 to 54; anal plate divided; tail length 20 to 26 per cent of total length; supralabials 6 + 6; infralabials usually 7 + 7; preoculars usually 2 + 2; postoculars usually 2 + 2; groundcolor above black, gray, or brown, with three light spots just behind head, sometimes with a light middorsal band; ventral color deep red or pale orange; usually a small but conspicuous light blotch on the fifth supralabial.

Variation.—Males of the northern red-bellied snake have higher caudal counts, proportionately longer tails, and lower ventral counts than females, table 75. Juvenile snakes tend to have more distinct occipital light spots than adults. Too few juvenile specimens are available to permit discerning other ontogenetic variation.

No definite clinal variation has been discerned in the small series available for study. The 32 specimens for which scale counts have been made are separable into a northern and a southern Illinois sample; the scutellation data for the two samples are offered separately, table 76, for what they may be worth.

In other features of scutellation, individual variation for the 32 specimens is as follows: scale rows 15 in 91 per cent of specimens, 16-15-15 in 3 per cent, 15-15-14 in 3 per cent, and 14-15-13 in 3 per cent; supralabials 5 + 6 in 4 per cent, 6 + 6 in 74 per cent, 6 + 7 in 22 per cent; infralabials 7 + 7 in 84 per cent, 7 + 8 in 13 per cent, 8 + 8 in 3 per cent; preoculars 2 + 2 in 93.0 per cent, 1 + 2 in 3.5 per cent, 2 + 3 in 3.5 per cent; postoculars 2 + 2 in 100 per cent.

Color in the 32 specimens is sufficiently variable to suggest two different species of snakes, if the extremes are compared. Although specimens that are intermediate in color occur, the majority of the Illinois specimens tend to be separable into two color phases. In the more common phase the snakes are dark gray to almost black above and have a sharply delineated red ventral color. In this phase there is often a light middorsal band that is sometimes margined with dark flecks. In the other phase the

snakes are tan or red-brown, with an orange ventral color that tends to merge gradually with the brown color of the sides; the occipital light spots are less prominent than on the dark phase. If two color phases are recognized, the phenomenon is of limited geo-

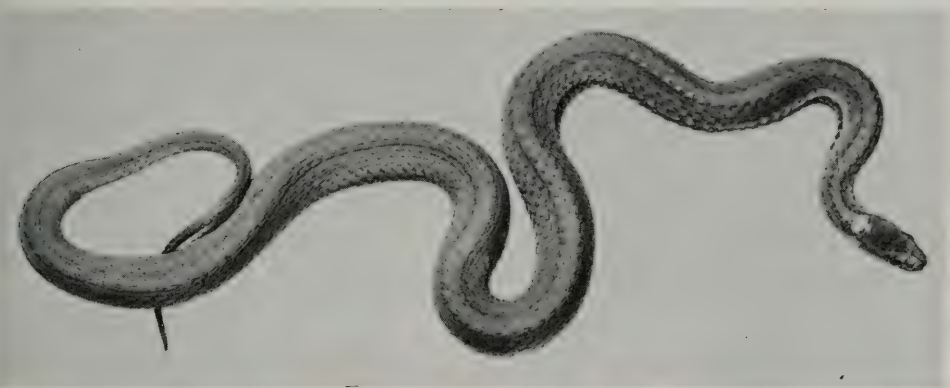


Fig. 227.—An adult *Storeria occipitomaculata occipitomaculata* from Piatt County, Illinois. The groundcolor above is grayish black or red-brown; below, red or orange.

Table 75.—Sexual variation in Illinois *Storeria occipitomaculata occipitomaculata*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (12)		FEMALES (19)	
	Range	Mean	Range	Mean
Ventrals.....	117-126	121.5	121-130	125.6
Caudals.....	47-54	51.0	41-49	44.5
Tail length as percentage of total length.....	22.0-25.8	24.1	19.9-24.4	21.4

Table 76.—Geographic variation in Illinois samples of *Storeria occipitomaculata occipitomaculata*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHERN ILLINOIS (5 MALES, 8 FEMALES)		SOUTHERN ILLINOIS (7 MALES, 12 FEMALES)	
	Range	Mean	Range	Mean
Ventrals				
Male.....	117-126	121.0	119-126	122.0
Female.....	123-130	126.5	121-128	124.9
Caudals				
Male.....	48-56	52.2	47-53	50.2
Female.....	41-47	44.7	41-49	44.4
Tail length as percentage of total length				
Male.....	22.0-25.8	24.3	22.8-24.8	23.9
Female.....	19.9-22.7	21.3	19.9-24.4	21.5

graphic significance, as snakes of each type have been found together on several occasions. The material available, however, suggests that the darkly pigmented form (hence more sharply bicolored snakes) is the one that occurs more frequently in northern Illinois; 11 of 12 specimens from the northern part of the state are dark, whereas 15 of 20 specimens from the southern part of the state are dark.

Some specimens have numerous dark dots or dashes outlining the middorsal light stripe and also have light flecks on the lowermost row of scales and adjacent ventral edges separated from the red ventral color by a row of dark spots. The width of the red ventral color varies; it depends on how far ventrad the dorsal color encroaches. The red ventral color tends to be narrower in the northern than in the southern specimens.

Habits.—This small snake is similar to *Storeria dekayi wrightorum* in most respects. Although it is sometimes found in pastures and wet meadows, it usually inhabits wooded areas. On two occasions individuals have been seen climbing in vegetation above the ground. Captive specimens, according to Pope (1944b), feed on earthworms and slugs. The broods are small and probably are born in August or September. A captive specimen gave birth to 14 young in early September.

Illinois Distribution.—The northern red-bellied snake is a forest species, and its occurrence in all parts of Illinois, fig. 228, including predominantly prairie areas, is surprising, particularly in view of its limited occurrence in Indiana and Ohio. Trapido (1944) regarded the only central Illinois locality known to him (Menard County) as doubtful and suggested that the species was absent in the steppe peninsula of Illinois, Indiana, and Ohio. Recent records show that the species occurs throughout Illinois but it is distinctly uncommon except in the forested morainal region of Cook and Lake counties.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: Braeside (Schmidt & Necker 1935); Evanston (Trapido 1944); Niles Center, Palos Park (Schmidt & Necker 1935); River Forest (Weed 1922); Thatcher Woods (Trapido 1944); Willow

Springs (Schmidt & Necker 1935); McLEAN COUNTY: Normal (H. Garman 1892); MENARD COUNTY: Athens (Trapido 1944); UNION COUNTY: Anna (H. Garman 1892).



Fig. 228.—Distribution of *Storeria occipitomaculata*. The subspecies *occipitomaculata* apparently occurs in wooded areas throughout Illinois. Solid circles indicate localities represented by specimens examined during this study; open circles, published records believed to be valid. The lower map depicts the total range of this widespread species in the United States.

Natrix Laurenti

Nine species, several with subspecies, of this world-wide genus occur in the United States and Canada. Ten species and subspecies are known in Illinois.

Natrix cyclopion cyclopion (Duméril, Bibron, & Duméril) Green Water Snake

Tropidonotus cyclopion Duméril, Bibron, & Duméril 1854:576 (type locality: New Orleans, Louisiana).

Natrix cyclopion, Jordan 1888:194.

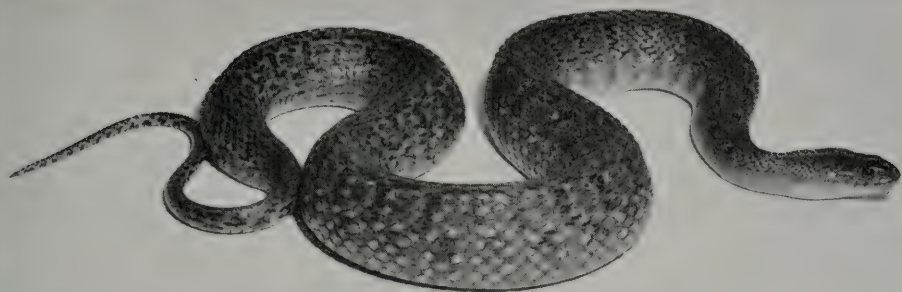


Fig. 229.—An adult *Natrix cyclopion cyclopion* from Harris County, Texas. The ground-color is usually olive; the rather indistinct pattern, brown or black. (Photo by Isabelle Hunt Conant.)

Natrix cyclopion cyclopion, Curran & Kauffeld 1937:261.

Tropidonotus cyclopium, Yarrow 1882a:137.

Nerodia cyclopium, H. Garman, 1892:271-2.

Natrix cyclopium, Cope 1892:673.

Diagnosis.—A large, heavy-bodied water snake (largest Illinois specimen 1,000 mm. in total length), fig. 229, with 23 to 29 anterior and 21 posterior rows of strongly keeled scales; ventrals 141 to 144; caudals 59 to 68; anal plate divided; supralabials usually 8 + 8; infralabials 10 to 13 on each side; preoculars 1 or 2; postoculars 2 or 3 on each side; suboculars always separating eye from supralabials; groundcolor greenish brown or olive-brown, with approximately 50 narrow, dim black crossbars; ventral color predominantly dark brown posteriorly and blotched with semicircles and squares of yellowish white.

Variation.—Scale counts for the three females and one male of the green water snake available from Illinois are as follows: scale rows 29-27-21, 27-27-21, 27-29-21, and 27-24-21; ventrals 142, 141, 143, and 144; caudals 59, 61, 62, and 68; supralabials 8 + 8 in three specimens, 8 + 9 in one; infralabials 10 + 10, 13 + 11, 12 + 12, and 11 + 11; tail length 21.8, 19.8, 22.6, and 21.0 per cent of total length. The dorsal pattern is dim on all specimens, and the crossbars cannot be counted with accuracy.

Habits.—No information is available concerning the habits of *Natrix cyclopion* in the northern part of its range. On the Gulf Coast, this large water snake inhabits lakes and swamps. Its food consists of fish and amphibians. Like most of the large water snakes, it is pugnacious in behavior.

The young are surprisingly large at birth.

The size of the brood varies with the age and size of the mother snake.

Illinois Distribution.—The green water snake, *N. c. cyclopion*, is known in Illinois

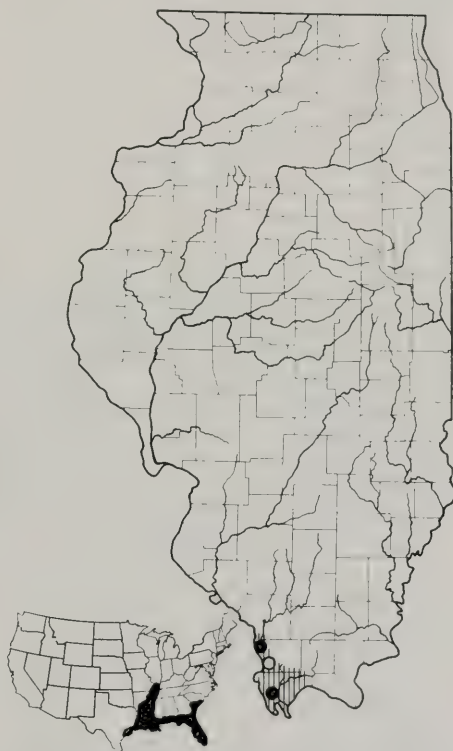


Fig. 230.—Distribution of *Natrix cyclopion*. Hatching indicates the presumed range of the subspecies *cyclopion* in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed valid. The lower map depicts the species range in the United States.

only from the extreme southern part of the state, fig. 230. Until quite recently the species was known here by only three CNHM specimens, collected at Olive Branch in 1907, and one equally old USNM specimen bearing the label "southern Illinois." Considerable field work by many different collectors in extreme southern Illinois failed to yield additional specimens until late 1956, when a juvenile was found at Pine Hills Recreation Area in Union County (Keiser 1958). Since that time nearly a dozen specimens have been collected at the same locality, but unfortunately they have not been available to me for study. The reasons for the relative abundance of this snake at present and its apparent rarity prior to 1956 are not known.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: UNION COUNTY: Bluff Lake (H. Garman 1892).

Natrix erythrogaster Forster

Four subspecies of the copper-bellied water snake are recognized, two of which occur in Illinois. An eastern race traverses

extreme southern Illinois, intergrading with a Gulf Coast race in the Mississippi River valley.

Natrix erythrogaster flavigaster Conant Yellow-Bellied Water Snake

Natrix erythrogaster flavigaster Conant 1949: 2, fig. 3 (type locality: Frenier Beach, St. John the Baptist Parish, Louisiana).

Tropidonotus sipedon erythrogaster nec Forster, Yarrow 1882a:136 (1).

Nerodia sipedon erythrogaster nec Forster, H. Garman 1892:269-71 (1).

Natrix fasciata erythrogaster nec Forster, Cope 1900:977 (1).

Natrix sipedon erythrogaster nec Forster, Jordan 1929:241 (1).

Natrix erythrogaster erythrogaster nec Forster, Conant 1938:71 (1).

Natrix sipedon erythrogaster nec Forster, Hurter 1893:257 (1).

Diagnosis.—A large, heavy-bodied water snake (largest Illinois specimen 1,316 mm. in total length), fig. 231, usually with 23 anterior and 17 posterior rows of strongly keeled scales; ventrals 145 to 156; caudals 59 to 84; anal plate divided; 8 + 8 supralabials; usually 10 + 10 infralabials; usually 1 preocular and 3 postoculars on each side; groundcolor (except in juveniles) uni-



Fig. 231.—An adult *Natrix erythrogaster neglecta* × *flavigaster* intergrade from Alexander County, Illinois. The groundcolor above is black, dark brown, or very dark olive-gray; below, orange and black in *neglecta* and yellow in *flavigaster*.

Table 77.—Sexual variation in Illinois *Natrix erythrogaster*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (17)		FEMALES (18)	
	Range	Mean	Range	Mean
Caudals.	67-84	78.2	59-72	67.2
Tail length as percentage of total length.	21.4-25.8	23.8	19.4-23.7	21.4

formly dark brown or black above, yellow below; venter usually unmarked except for slight encroachment of dark dorsal color on lateral edges of ventral scutes; groundcolor of juveniles gray, with 29 to 35 closely crowded black dorsal blotches; venter of juveniles yellowish white, with a narrow dark transverse bar bordering each ventral scute.

Variation.—Males of *Natrix erythrogaster* have longer tails than females and accordingly have higher caudal counts. Since lepidosis in the two Illinois races, *neglecta* and *flavigaster*, is identical, data on sexual dimorphism for these races are combined in table 77.

The baby snakes are blotched; the sub-adults become uniformly dark above and yellow below. Traces of the blotched pattern are retained in occasional specimens 700 mm. in total length. The venter is usually unmarked, except for the lateral edges of the ventral scutes in specimens 500 mm. or more in length and in juveniles.

Geographic variation in color and pattern is rather pronounced in this snake. The more northern specimens are yellow below, with the dark groundcolor of the upper parts encroaching a short distance on each posterior ventral. Anteriorly the ventrals are plain. In a series from extreme southwestern Illinois some specimens have this pattern type and some have a pattern in which the venter is orange and the dorsal color traverses the venter, reducing the ventral color to a median series of orange semilunar markings. Other specimens in the series are approximately intermediate but show a more pronounced influence of the latter pattern type. These extreme southwestern Illinois specimens are intergrades between *neglecta* and *flavigaster*.

Individual variation in scutellation for *N. e. flavigaster* and *N. e. neglecta* is unimodal, and therefore the counts have been

summarized as follows for the 35 Illinois specimens of *N. erythrogaster* studied: ventrals 145 to 156 (average 150.5); anterior scale rows 19 in 3 per cent of specimens, 21 in 13 per cent, 22 in 11 per cent, 23 in 73 per cent; scale rows at mid-body 20 in 3 per cent, 21 in 6 per cent, 22 in 17 per cent, 23 in 65 per cent, 24 in 3 per cent, and 25 in 6 per cent; posterior scale rows 16 in 11 per cent, 17 in 68 per cent, 18 in 16 per cent, 19 in 5 per cent; supralabials 8 + 8 in 100 per cent; infralabials 10 + 10 in 87 per cent, 11 + 11 in 13 per cent; preoculars 1 + 1 in 90 per cent, 1 + 2 in 5 per cent, 2 + 2 in 5 per cent; postoculars 2 + 3 in 8 per cent, 3 + 3 in 78 per cent, 3 + 4 in 11 per cent, and 3 + 5 in 3 per cent.

Habits.—Like the green water snake, this large water snake shows a preference for the quiet waters of ponds, lakes, and swamps. Cornered individuals strike viciously and when captured excrete foul-smelling material on the collector. At Horseshoe Lake, Alexander County, this snake congregates in numbers at the spillway, where it captures the fish carried over the retaining wall. Catfishes frequently are found in the stomachs of yellow-bellied water snakes, which eat frogs and probably crayfish also. The yellow-bellied water snake apparently leaves hibernation early in the spring; active specimens have been seen the first part of March.

Cagle (1942a) records copulation of these snakes in May and the presence of 28 large ovarian eggs in a female. The young captured in the fall are considerably smaller than new-born individuals of *N. cyclopion*.

Illinois Distribution.—The range of *N. e. flavigaster* in its typical form, as indicated by the few available specimens, is puzzling, fig. 232. Although the distribution of this subspecies centers in the lower Mississippi River valley, all of the Illinois specimens of seemingly pure *flavigaster* are from

north of the Shawnee Hills region. The extreme southwestern Illinois specimens which could more logically be expected to display *flavigaster* characters are actually *neglecta* $\times$ *flavigaster* intergrades. *N. e. flavigaster*, at least formerly, extended up the Illinois River. Conant (1949) viewed Garman's Peoria record with doubt, but I once examined a specimen of *flavigaster*, in the collection of H. J. Van Cleave, labeled "Havana, Illinois." Havana is only a few miles south of Peoria. This specimen has since been lost, but others are extant from Calhoun County, the eastern border of which is on the Illinois River. Specimens from the Mississippi River floodplain (Alexander to Jackson counties) are *neglecta* $\times$ *flavigaster*.

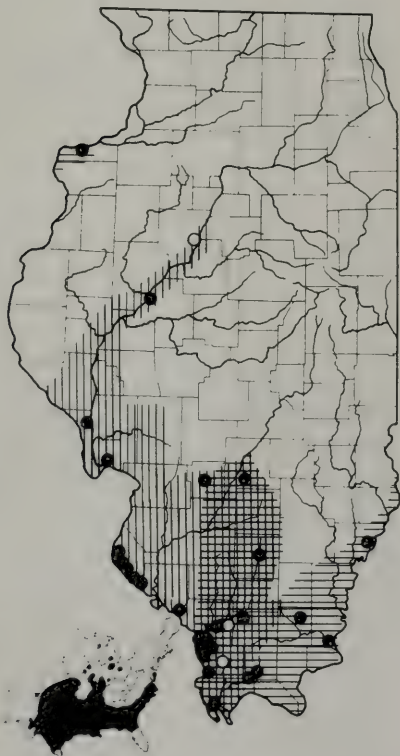


Fig. 232.—Distribution of *Natrix erythrogaster*. Vertical hatching indicates the presumed range of the subspecies *flavigaster* in Illinois; horizontal hatching, the presumed range of the subspecies *neglecta*; crosshatching, the area of intergradation between the two subspecies; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Carbondale, Crab Orchard (Cagle 1942a); PEORIA COUNTY: Peoria (H. Garman 1892); UNION COUNTY: Anna (H. Garman 1892).

***Natrix erythrogaster neglecta* Conant**
Northern Copperbelly
Red-Bellied Water Snake

Natrix erythrogaster neglecta Conant 1949:5, fig. 1 (type locality: 3 mi. E Mount Victory, Hardin County, Ohio).

Tropidonotus sipedon erythrogaster nec Forster, Yarrow 1882a:136 (1).

Nerodia sipedon erythrogaster nec Forster, H. Garman 1892:269-71 (1).

Natrix sipedon erythrogaster nec Forster, Jordan 1929:241 (1).

Natrix erythrogaster erythrogaster nec Forster, Conant 1938:7 (1).

Natrix sipedon erythrogaster nec Forster, Hurter 1911:155 (1).

Diagnosis.—A subspecies of *Natrix erythrogaster* (largest Illinois specimen 1,082 mm. in total length), fig. 231, differing from *N. e. flavigaster* in color and pattern as follows: groundcolor above black, below bright orange; dark groundcolor of dorsum encroaching well onto the venter; orange ventral color usually reduced posteriorly to a median series of narrow, orange, semilunar markings.

Variation.—Sexual and ontogenetic variation in *N. e. neglecta* parallels that in *N. e. flavigaster*. The juvenile blotched pattern appears to be lost at a smaller size in *neglecta*, however, probably because this subspecies has a more intense black pigment on the dorsum.

Individual variation for the species is as described in the discussion of *N. e. flavigaster*.

Habits.—The northern copperbelly is similar in habits to the yellow-bellied water snake. East of Illinois it frequents bogs.

Illinois Distribution.—The northern copperbelly is apparently uncommon in Illinois, fig. 232. Although few specimens have been collected, this subspecies probably occurs throughout the lower Wabash and Ohio River valleys. The northernmost record, from an island in the Mississippi River, suggests a relict distribution elsewhere.

Natrix grahami (Baird & Girard)
Graham's Water Snake

Regina grahamii Baird & Girard 1853:47 (type locality: Rio Salado; revised to Salado Creek, Bell County, Texas, by Schmidt 1953); Kennicott 1855:592.
Tropidonotus grahamii, Hay 1891:113.
Natrix grahamii, Hay 1892a:589.
Tropidonotus grahami, Yarrow 1882a:131.
Regina grahami, H. Garman 1892:273-4.
Natrix grahami, Hurter 1893:257.
Tropidonotus leberis, Davis & Rice 1883a:30.
Regina leberis, H. Garman 1889:132.
Natrix rigida nec Say, McLain 1899:3.

Diagnosis.—A medium-sized, moderately stout-bodied water snake (largest Illinois specimen 854 mm. in total length), fig. 233, usually with 20-19-17 rows of strongly

keeled scales; ventrals 158 to 173; caudals 54 to 67; anal plate divided; supralabials 7, occasionally 8 on each side; infralabials 8 to 10 on each side; groundcolor brown or dark olive above, with a yellow or a light olive-green stripe along either side of the body, involving the lower three scale rows; lateral stripe prominently bordered below by a narrow, irregular black stripe along the outer edges of the ventrals; lateral stripe sometimes bordered above by a dark line; median light stripe 2 to 3 scale rows in width sometimes present; venter yellow or greenish white, with faint median dark line or row of dots on posterior third of belly.

Variation.—Males in this species differ from females in the somewhat higher ventral



Fig. 233.—An adult *Natrix grahami* from Cumberland County, Illinois. The groundcolor is olive or grayish brown; the lateral bands and venter are greenish gray or yellowish white.

Table 78.—Sexual variation in Illinois *Natrix grahami*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (15)		FEMALES (16)	
	Range	Mean	Range	Mean
Ventrals.....	162-175	169.1	155-169	160.9
Caudals.....	60-67	64.0	54-64	57.4
Tail length as percentage of total length.....	17.4-20.4	19.1	16.0-20.1	18.2

Table 79.—Geographic variation in Illinois *Natrix grahami*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	NORTHERN ILLINOIS (13)		CENTRAL ILLINOIS (11)		SOUTHERN ILLINOIS (8)	
	Range	Mean	Range	Mean	Range	Mean
Ventrals						
Male.....	162-170	165.7	171-172	171.3	167-175	171.7
Female.....	158-169	161.6	155-163	159.5	159-163	160.3
Caudals						
Male.....	62-65	63.8	60-67	63.7	63-66	64.5
Female.....	57-64	59.5	54-57	55.7	55-60	57.0
Tail length as percentage of total length						
Male.....	18.3-20.4	19.5	18.7-20.4	19.5	17.4-19.8	18.5
Female.....	17.0-19.7	18.8	17.4-20.1	18.3	16.0-17.7	17.1

and caudal counts and slightly longer tails, table 78.

The juveniles differ from the adults in the greater contrast between dorsal groundcolor and color of the lateral stripes. The venter and lateral stripes are more yellowish in young and the occurrence of a middorsal light band, bordered by dark lines, is more frequent in juveniles.

There is some evidence that in specimens from the northern part of Illinois the mid-ventral stripe or median series of dark spots on the posterior part of the belly is more prominent than in specimens from the southern part. Also, a smaller number of ventrals in northern males is suggested, as shown by a comparison of the means of samples from northern, central, and southern Illinois, table 79.

Individual variation in scale rows, labials, and oculars in a sample of 31 specimens is as follows: anterior scale rows 20 in 67 per cent of specimens, 19 in 33 per cent; scale rows at mid-body 19 in 100 per cent; posterior scale rows 17 in 92 per cent, 18 in 4 per cent, 19 in 4 per cent; supralabials 7 + 7 in 72 per cent, 7 + 8 in 16 per cent, 8 + 8 in 12 per cent; infralabials 8 + 8 in 8 per cent, 8 + 9 in 16 per cent, 9 + 9 in 52 per cent, 9 + 10 in 16 per cent, 10 + 10 in 4 per cent, 9 + 11 in 4 per cent; preoculars 1 + 2 in 4 per cent, 2 + 2 in 96 per cent; postoculars 1 + 2 in 8 per cent, 2 + 2 in 65 per

cent, 2 + 3 in 19 per cent, and 3 + 3 in 8 per cent.

Habits.—This striped water snake is found in sluggish water areas such as lakes, river-bottom sloughs, and prairie marshes. Newly captured specimens do not bite, but they are unpleasant to handle because of the quantity of fecal matter they expel. Individuals may be seen basking on rock piles around lakes and on branches overhanging the water. They are shy and usually difficult to catch. Graham's water snake feeds largely on newly molted crayfish. It feeds on fish and amphibians also.

A captive individual of this species had 9 young on August 15.

Illinois Distribution.—Although Graham's water snake occurs in most of Illinois, fig. 234, it reaches the eastern limit of its range in this state and has never been recorded from Indiana. It probably occurs throughout Illinois except for the Wabash and Ohio River counties.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: BUREAU COUNTY: Milo (Cope 1900); COOK COUNTY: Glenview (Schmidt & Necker 1935); FRANKLIN COUNTY: West Frankfort (Cagle 1942a); JACKSON COUNTY: Murphysboro (Cagle 1942a); KANE COUNTY: Geneva (H. Garman 1892); KNOX



Fig. 234.—Distribution of *Natrix grahami*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

COUNTY: Galesburg (H. Garman 1892); MADISON COUNTY: (Hurter 1911); PERRY COUNTY: Du Quoin (Cagle 1942a); ST. CLAIR COUNTY: opposite St. Louis (Hurter 1911); TAZEWELL COUNTY: Pekin (H. Garman 1892).

***Natrix kirtlandi* (Kennicott)**
Kirtland's Water Snake

Regina kirtlandii Kennicott 1856:95 (type locality: northern Illinois; revised to West Northfield, Illinois, by Conant 1943).

Tropidoclonion kirtlandii, Cope 1860b:340.

Tropidoclonium kirtlandii, Cope 1875:42.

Tropidonotus kirtlandii, S. Garman 1883:29, 143.

Clonophis kirtlandii, Cope 1892:674.

Ischnognathus kirtlandii, Boulenger 1893:286.

Natrix kirtlandii, Cope 1900:997.

Tropidoclonium kirtlandii, Jordan 1878:176.

Tropidonotus kirtlandii, S. Garman 1884:24.

Clonophis kirtlandii, Jordan 1888:192.

Regina kirtlandii, H. Garman 1890:187.

Natrix kirtlandii, Hay 1892a:506.

Olonophis kirtlandii, Surface 1906:140.

Diagnosis.—A small, stout-bodied water snake (largest Illinois specimen 470 mm. in total length), fig. 235, usually with 19–19–17 rows of strongly keeled scales; ventrals 127 to 137; caudals 49 to 62; divided anal plate; supralabials usually 6 + 6; infralabials usually 7 + 7; preoculars usually 1 + 1; postoculars usually 2 + 2; groundcolor above gray or brown, on which are superimposed four rows of 46 to 57 round or nearly square black blotches, giving the dorsum a checkerboard appearance; blotches most distinct anteriorly and laterally, sometimes fading out middorsally on the posterior part of the body; venter bright red, brick red, or a faded orange, and bordered laterally by a series of dark spots on each side.

Variation.—Males in this species are proportionately longer tailed and shorter bodied than females. This dimorphism is illustrated in table 80.

In young Kirtland's water snakes the color is much darker than in adults, and the checkered dorsal pattern is not prominent. In baby snakes the head is black, and the venter is usually bright red. In older individuals the color appears to be somewhat faded, but the checkered or spotted pattern of the dorsum is more evident.

Too few specimens are available from extreme northern Illinois to indicate much in the way of geographic variation trends in this species. In a sample of 18 specimens from east-central Illinois, 11 are females with the following variation: ventrals 129 to 137 (average 132.9); caudals 49 to 57 (average 53.2); lateral body spots 46 to 56 (average 50.8); and tail length 19.7 to 23.4 (average 20.8) per cent of total length. The three specimens from northeastern Illinois, all of which are females, have ventrals 130 to 133 (average 131); caudals 51 to 54 (average 52.6); lateral body spots 46 to 59 (average 54.6); and tail length 19.5 to 19.9 (average 19.7) per cent of total length. Thus, a reduction in number of scales and proportionate tail length and an increase in number of spots toward the north is suggested, but these characteristics are based on so few specimens that any apparent trends are of uncertain significance. Northern specimens tend to be darker.

Individual variation in number of labials and oculars for a series of 19 specimens is slight: supralabials 6 + 6 in 84 per cent of specimens, 5 + 6 in 16 per cent; infralabials 7 + 7 in 95 per cent, 7 + 8 in 5 per cent; preoculars 1 + 1 in 95 per cent, 2 + 2 in 5 per cent. Coloration is more variable. Some adults retain the jet black markings of juveniles; others have a faded appearance, with brown spots and a poorly defined middorsal gray stripe. The venter is bright brick-red or orange-red usually, but one adult taken near St. Joseph, Illinois, had an almost yel-

low venter. This oddly colored specimen escaped before it could be preserved.

Habits.—This small, innocuous water snake is the least aquatic of the Illinois species of *Natrix*. Specimens found during the day are almost invariably hiding beneath rocks, boards, or other objects. *N. kirtlandi* flattens its body when disturbed and remains so until touched. Then it uncoils violently and seeks to escape by wriggling away. Captives eat earthworms readily.

Copulation in this species has been observed on May 10 and May 14. Conant



Fig. 235.—An adult *Natrix kirtlandi* from Coles County, Illinois. The groundcolor above is gray or brown with black spots or squares arranged in checkerboard fashion; below, red or orange bordered by a row of black spots along each side.

Table 80.—Sexual variation in Illinois *Natrix kirtlandi*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (7)		FEMALES (14)	
	Range	Mean	Range	Mean
Ventrals.....	127-134	130.5	129-137	132.5
Caudals.....	58-62	59.8	49-57	53.0
Tail length as percentage of total length.....	22.1-25.2	23.9	19.5-23.4	20.6

(1943) recorded that, in Ohio, 4 to 13 young per female are born in August and September.

Illinois Distribution.—Kirtland's water snake is apparently restricted in Illinois to the northeastern and east-central part, north of the Shelbyville Moraine, fig. 236.* This snake is considered a glacial relict. Specimens have been found in vacant lots and in wooded ravines near Charleston and in ditches in cultivated fields near Urbana.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: COOK COUNTY: Evanston (Schmidt & Necker 1935); Palos Park, River Forest (Necker 1939c); West Northfield (Kennicott 1856).

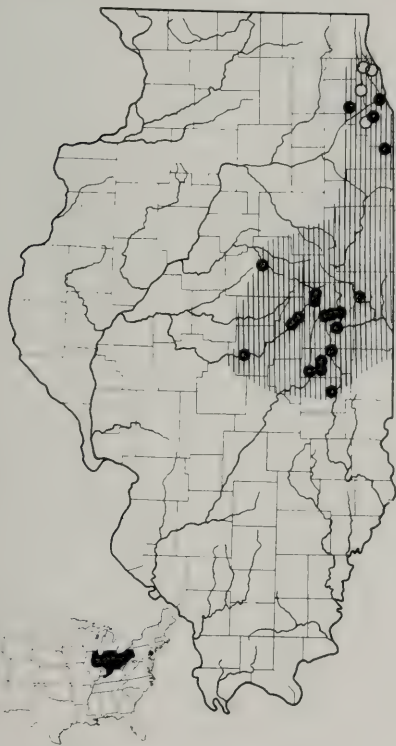


Fig. 236.—Distribution of *Natrrix kirtlandi*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

*Since this account was written, a specimen has been taken in southwestern McDonough County, extending the known range almost to the Mississippi River.

Natrrix rhombifera rhombifera (Hallowell)

Diamond-Backed Water Snake

Tropidonotus rhombifer Hallowell 1852:177
(type locality: Arkansas River and its tributaries near the northern boundary of the Creek Nation; revised to Fort Smith, Arkansas, by Schmidt 1953); Cope 1861:298.

Natrrix rhombifer, Jordan 1888:194.

Nerodia sipedon rhombifer, H. Garman 1892:269-71.

Natrrix rhombifera, Cope 1892:668, 673.

Natrrix rhombifera rhombifera, Clay 1938:177.

Diagnosis.—A large, heavy-bodied water snake (largest Illinois specimen 1,349 mm. in total length), fig. 237, with 24 to 28 rows of scales anteriorly and usually 21 rows posteriorly; scales strongly keeled; ventrals 135 to 146; caudals 59 to 82; anal plate divided; supralabials usually 8 + 8; infralabials 10 to 12 on each side; preoculars usually 1 + 1; postoculars 3 or 4 on each side; groundcolor yellow, gray, or light olive, with 25 to 37 dark lateral bands, most of which bifurcate dorsally, the dark, narrow processes crossing the back and meeting their partners, thus enclosing light, diamond-shaped middorsal blotches; venter predominantly yellow, with semilunar dark markings, which are most numerous posteriorly.

Variation.—Males of this water snake have higher average caudal counts and slightly longer tails than females, table 81. They also have slightly higher mean ventral counts and a tendency toward reduction of the number of scale rows around the body, but neither ventral nor scale row counts are constant enough to aid in sexing specimens.

Juveniles of the diamond-backed water snake differ from adults in the somewhat brighter pattern and more slender head and body.

No geographic variation trends have been discerned for this snake in Illinois, the means of scale and blotch counts of samples from various parts of the state being remarkably close. There is considerable individual variation in number of scale rows around the body. In 40 specimens the anterior scale rows are 24 in 2.5 per cent, 25 in 27.5 per cent, 26 in 27.5 per cent, 27 in 32.5 per cent, and 28 in 10.0 per cent. Scale rows at mid-body are 24 in 7.5 per cent of the specimens, 25 in 40.0 per cent, 26 in 25.0 per cent, 27 in 17.5 per cent, and 28 in 10.0 per cent. Pos-

terior scale rows are 19 in 2.5 per cent of the specimens, 20 in 5.0 per cent, 21 in 82.5 per cent, 22 in 5.0 per cent, and 23 in 5.0 per cent.

Individual variation in number of ventrals is not great, ranging in 40 specimens from 135 to 146, averaging 140.9. Supralabials are 7 + 7 in 2.5 per cent of the specimens, 7 + 8 in 2.5 per cent, 8 + 8 in 74.0 per cent, 8 + 9 in 9.2 per cent, 9 + 9 in 9.2 per cent, and 9 + 10 in 2.5 per cent. Infralabials are 10 + 10 in 9.5 per cent, 10 + 11 in 9.5 per cent, 11 + 11 in 59.5 per cent,

11 + 12 in 4.7 per cent, 12 + 12 in 12.0 per cent, and 12 + 13 in 4.7 per cent. Preoculars are 1 + 1 in 91.0 per cent, 1 + 2 in 2.5 per cent, 2 + 2 in 4.0 per cent, and 3 + 3 in 2.5 per cent. Postoculars are 2 + 3 in 5 per cent, 3 + 3 in 64 per cent, 3 + 4 in 26 per cent, and 4 + 4 in 5 per cent. The number of dark lateral bands in 40 specimens ranges from 25 to 37, averaging 31.5. In occasional specimens the lateral bands anteriorly have light-colored centers.

Habits.—The diamond-backed water snake is most abundant in the quiet waters

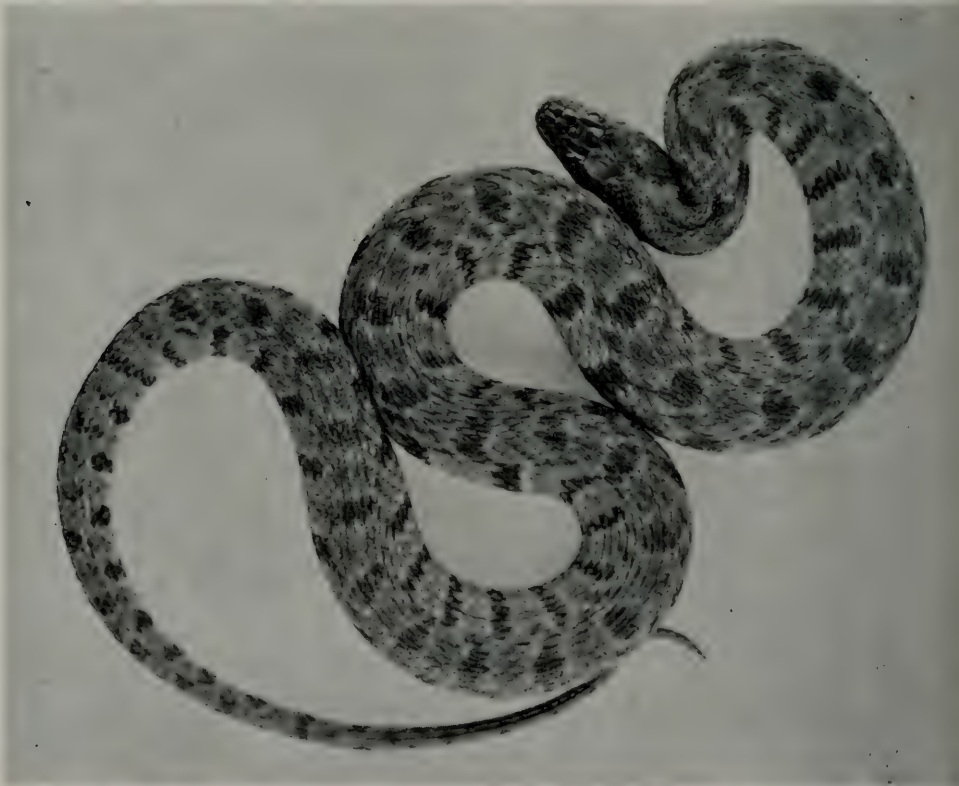


Fig. 237.—An adult *Natrix rhombifera rhombifera* from Alexander County, Illinois. The groundcolor above is dull yellow; the markings are olive or brown.

Table 81.—Sexual variation in Illinois *Natrix rhombifera rhombifera*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (16)		FEMALES (25)	
	Range	Mean	Range	Mean
Caudals.	71-82	74.6	59-68	61.8
Tail length as percentage of total length.	23.8-26.3	24.7	19.0-23.5	21.5

of shallow lakes, sloughs, and swamps. In the shallow marshes on the Mississippi floodplain of southern Illinois, this snake thrives in water that is so warm that a snake could hardly be expected to survive such a temperature. The diamond-back is an ill-tempered and unpleasant snake to collect. Its bite is painful and the excrement it voids is foul smelling. Although active individuals may be found in the daytime, the species is most active at night. It is fond of basking on limbs overhanging water, sometimes several feet high. It is primarily a fish eater, although captives take frogs readily.

Captives have had broods of 23 and 32 young in September and early October. The young are quite large at birth, averaging about 265 mm. in total length.

Illinois Distribution.—The diamond-backed water snake is very common in lakes,

ponds, and river sloughs of the Mississippi-Ohio river lowlands and in the Lower Mississippi Border floodplain sloughs. Elsewhere in the state it appears to be limited to the major rivers, occurring as far north as Fayette County on the Kaskaskia, Peoria County on the Illinois, and Henderson County on the Mississippi. No records are available for eastern Illinois except in the lower Wabash River. This species has been known previously in Illinois only in the southern tip of the state, and the specimens now at hand extend the known range approximately 175 miles northward in the Mississippi River valley, fig. 238. Garman's (1892) record for Cook County is far outside the known range of the species and undoubtedly in error.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: JACKSON COUNTY: Grimsby (Cagle 1942a); Murphysboro (Ditmars 1945); MADISON COUNTY: (Hurter 1897); WABASH COUNTY: Mount Carmel (Yarrow 1882a).

Natrix septemvittata (Say)
Queen Snake

Coluber septemvittatus Say 1825:240 (type locality: Pennsylvania).

Natrix septemvittata, Weed 1922:87.

Regina leberis, Kennicott 1855:592.

Tropidonotus leberis, Ditmars 1907:243.

Regina rigida nec Say, Jordan 1888:193.

Diagnosis.—A medium-sized, moderately stout-bodied water snake (largest Illinois specimen 890 mm. in total length), fig. 239, usually with 19–19–17 rows of strongly keeled scales; ventrals 140 to 153; caudals 68 to 85; anal plate divided; supralabials 7 + 7; infralabials 8 to 10 on a side; preoculars 2 + 2; postoculars 2 + 2; ground-color dark brown or dark gray, with a yellow or yellow-white stripe along either side of body involving most of the first and second rows of scales; lateral edges of ventrals brown, forming a distinct dark lateroventral stripe on each side; venter yellow, with a pair of dark median longitudinal stripes extending from about the fifteenth ventral to the tip of the tail, or venter much suffused with dark and having a narrow median light stripe present; middorsal light band or narrow dark line sometimes present.



Fig. 238.—Distribution of *Natrix rhombifera*. Hatching indicates the presumed range of the subspecies *rhombifera* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the species range in the United States.

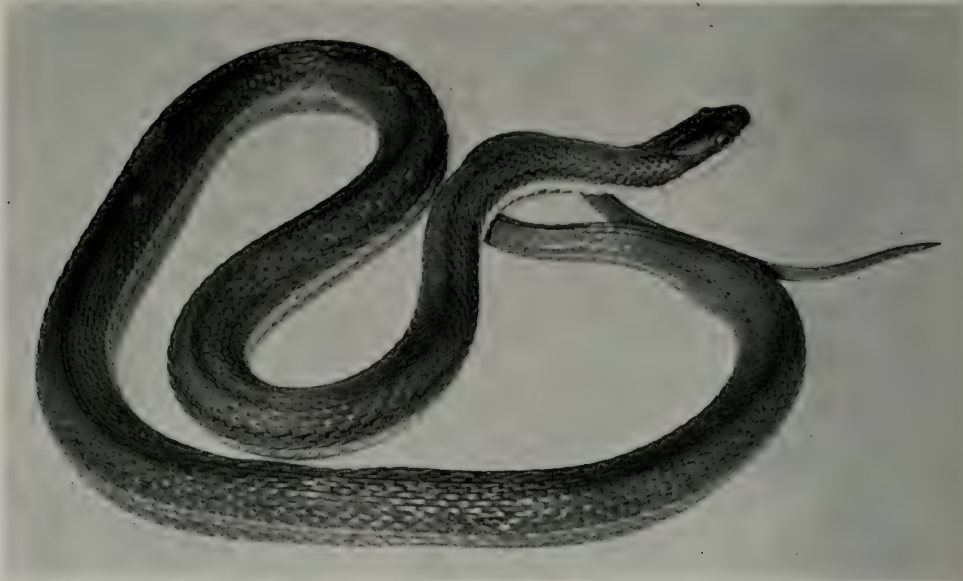


Fig. 239.—An adult *Natrix septemvittata* from Vermilion County, Illinois. The groundcolor above is dull brown; the lateral stripes are grayish yellow; the groundcolor below is dull yellow with a pair of longitudinal red-brown stripes.

Table 82.—Sexual variation in Illinois *Natrix septemvittata*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (10)		FEMALES (20)	
	Range	Mean	Range	Mean
Caudals.....	78-85	80.5	68-78	72.2
Tail length as percentage of total length.....	26.0-28.6	27.2	19.9-26.9	24.5

Variation.—The male of *Natrix septemvittata* has a slightly longer tail and a greater number of caudals than the female, table 82.

The juveniles differ from the adults in having a more pronounced pattern. Young snakes have two distinct dark midventral stripes and a conspicuous light ventrolateral stripe on each side of the body. In many older snakes the ventral stripes are obscured by dark mottling on the posterior part of the belly and the lateral stripe fades out on the posterior third of the body.

No geographic variation for this snake has been discerned within Illinois. The average number of caudals is higher in Illinois than in the Ohio specimens, studied by Wood & Duellman (1950). Individual variation in a sample of 31 Illinois specimens is as follows: ventrals 140 to 153 (average 145.6); 18 anterior scale rows in 3 per cent

of specimens, 19 in 57 per cent, 20 in 37 per cent, and 21 in 3 per cent; 19 scale rows at mid-body in 90 per cent, 18 in 7 per cent, and 17 in 3 per cent; 17 posterior scale rows in 100 per cent; supralabials 7 + 7 in 90 per cent, 6 + 7 in 7 per cent, 7 + 8 in 3 per cent; infralabials 10 + 10 in 52 per cent, 9 + 10 in 21 per cent, 9 + 9 in 17 per cent, 8 + 9 in 7 per cent, and 8 + 8 in 3 per cent; preoculars 2 + 2 in 100 per cent; postoculars 2 + 2 in 97 per cent, and 2 + 1 in 3 per cent.

Habits.—This slender, innocuous water snake is the stream counterpart of *N. grahami*. The two species are similar in appearance as well as in habits but they are unlike in habitat preference; the queen snake occurs in fast streams in forested regions, Graham's water snake in sluggish water in prairie areas. *N. septemvittata* is shy and it is difficult to capture except when

under rocks. Like Graham's water snake, this species apparently feeds chiefly on newly molted crayfish. Newly captured individuals have been known to regurgitate small fish.

Three captive females gave birth to broods of 7, 9, and 12 young in late August.

Illinois Distribution.—The queen snake occurs in the northeastern quarter of Illinois, west at least to Ogle and Fulton coun-

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: **COOK COUNTY:** Bowmanville, Evanston, Glencoe, Lambert, Palos Park, Willow Springs (Schmidt & Necker 1935); **GRUNDY COUNTY:** Morris (Stille & Edgren 1948).

Natrix sipedon (Linnaeus)

Ten subspecies of *Natrix sipedon* are recognized in the United States and Canada; three of them occur in Illinois. The nominate race and an Interior Low Plateau race (*pleuralis*) intergrade in an extremely wide belt across central Illinois. A distinctive race of the lower Mississippi River valley (*confluens*) extends northward to the southern tip of the state. Intergradation between *confluens* and *pleuralis* has not been clearly demonstrated.

Natrix sipedon sipedon (Linnaeus)

Northern Water Snake

Coluber sipedon Linnaeus 1758:219 (type locality: North America; revised to vicinity of New York City by Schmidt 1953).

Nerodia sipedon, Kennicott 1855:592.

Tropidonotus sipedon sipedon, Yarrow 1882a: 134-5.

Nerodia sipedon sipedon, H. Garman 1892:269-72.

Natrix sipedon, Hurter 1897:500 (I).

Natrix fasciata sipedon, Cope 1900:971-2.

Natrix sipedon sipedon, Van Cleave 1928:133, 136.

Tropidonotus sipedon woodhousei, Cope 1877: 64.

Natrix sipedon woodhousei, Jordan 1888:194.

Natrix fasciatus nec Linnaeus, Gaige 1914:4 (I).

?*Natrix* sp., Hankinson 1910:25 (I).

Diagnosis.—A large, heavy-bodied water snake (largest Illinois specimen 1,229 mm. in total length), fig. 241, with 23 anterior and 17 or 19 posterior rows of strongly keeled scales; ventrals 135 to 149; caudals 58 to 80; anal plate divided; supralabials usually 8 + 8; infralabials usually 10 or 11 on each side; preoculars usually 1 + 1; postoculars 3 + 3; groundcolor gray, tan, or light brown, with 30 or more red-brown or dark brown dorsal blotches or transverse bands; usually less than 10 transverse bands, succeeded by 20 or more dorsal blotches that alternate with lateral dark bars; lateral

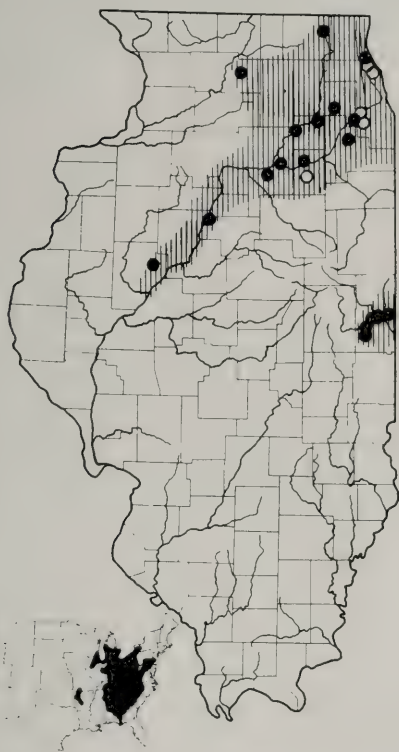


Fig. 240.—Distribution of *Natrix septemvittata*. Hatching indicates the presumed range of the species in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

ties and south to Vermilion County, fig. 240. The species is most abundant along small, rocky streams in the wooded areas near the Indiana-Illinois state line. The known localities in Fulton, Woodford, and La Salle counties probably represent a southwestern extension of range along the wooded bluffs of the upper Illinois River, since specimens have not been found in the adjacent prairie counties of central Illinois.



Fig. 241.—An adult *Natrix sipedon sipedon* from Will County, Illinois. The groundcolor is gray or light brown; the blotches are red-brown or brownish black.

Table 83.—Sexual variation in Illinois *Natrix sipedon*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (21)		FEMALES (30)	
	Range	Mean	Range	Mean
Caudals.....	72-80	75.5	57-72	63.2
Tail length as percentage of total length.....	23.5-27.3	25.6	20.5-24.8	22.6

Table 84.—Geographic variation in pattern features of Illinois *Natrix sipedon sipedon* and *N. s. sipedon* × *pleuralis* intergrades. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	AREA I* (10 MALES, 12 FEMALES)		AREA II* (13 MALES, 18 FEMALES)		AREA III* (11 MALES, 14 FEMALES)		AREA IV* (4 MALES, 7 FEMALES)		AREA V* (9 MALES, 11 FEMALES)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Body blotches and rings....	30-40	36.2	26-44	33.1	25-35	31.3	25-33	28.8	24-30	26.4
Transverse body rings.....	5-17	9.2	5-29	11.6	6-30	13.9	7-18	12.0	5-28	13.1
Tail rings										
Male.....	20-27	24.5	16-23	19.7	16-23	19.7	17-25	21.5	18-29	20.8
Female.....	17-26	21.5	16-22	18.1	16-22	18.1	15-23	19.0	14-19	15.6

	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
Lateral blotches narrower than interspaces.....	0.9		9.6		17.0		50.0		45.0	
Lateral blotches wider than interspaces.....	68.0		51.0		62.0		20.0		10.0	

*Area I is approximately the northern third of Illinois. Area II is east-central Illinois, the region enclosed by Vermilion and Clark, Logan and Christian counties. Area III is west-central Illinois, the area enclosed by Mercer, Fulton, and Jersey counties. Area IV is southwestern Illinois; it includes the counties from Madison and Fayette south through Randolph and Franklin counties. Area V is southeastern Illinois; it includes the region enclosed by Crawford and Effingham through Wabash and Wayne counties. The sample from Area I consists of genetically pure *N. s. sipedon*; samples from all other areas are *N. s. sipedon* × *pleuralis* intergrades.

dark bars usually wider than light interspaces; tail usually with 20 or more dark rings; venter with numerous semilunar brown or red markings, occasionally the ventral pattern almost obliterated by dark stippling.

Variation.—The male of the northern water snake is longer tailed than the female. Sexual variation is identical in *Natrix sipedon sipedon* and the allied race, *N. s. pleuralis*. It is illustrated by 51 specimens of both races as well as by intergrade specimens, table 83.

The number of dark tail rings varies both sexually and geographically. The male of *N. s. sipedon* has 20 to 27 (average 24.5) rings; the female has 17 to 26 (average 21.5). The number of tail rings in individuals decreases toward the south, but the males continue to average 1 to 3 more rings than females.

Juveniles of this subspecies differ from the adults in the greater contrast between groundcolor and blotches; in baby snakes the blotches appear almost black on a white background. The ventral markings are black in young, brown or reddish in subadults.

The only geographic variation discerned in this snake is in pattern. Lepidosis is apparently identical in all Illinois subspecies of *N. sipedon*. The pattern variation consists of a reduction, from north to south, in the number of dorsal blotches and tail rings, a narrowing in width of these markings, and a proportionately higher number of transverse bands at the expense of the alternating dorsal and lateral blotches. These trends are illustrated in table 84.

Inasmuch as scutellation is apparently identical in *N. s. sipedon* and *N. s. pleuralis*, individual variation in scale counts has been summarized for 54 specimens of both races as well as intergrade specimens. Anterior scale rows are 22 in 4 per cent of the specimens, 23 in 87 per cent, 24 in 7 per cent, and 25 in 2 per cent; scale rows at mid-body are 22 in 11 per cent, 23 in 67 per cent, 24 in 20 per cent, and 25 in 2 per cent; posterior scale rows are 17 in 33 per cent, 18 in 37 per cent, and 19 in 30 per cent. Supralabials are 7 + 8 in 2 per cent, 8 + 8 in 89 per cent, 8 + 9 in 5 per cent, 9 + 9 in 2 per cent, and 8 + 10 in 2 per cent; infralabials are 10 + 9 in 2 per cent, 10 + 10 in 81 per cent, 10 + 11 in 9 per cent, 11 + 11 in 2 per cent, 12 + 12 in 4 per cent, and 10 + 12 in 2 per

cent; preoculars 1 + 1 in 94 per cent, 1 + 2 in 4 per cent, and 2 + 2 in 2 per cent; postoculars 2 + 2 in 9 per cent, 3 + 3 in 82 per cent, and 2 + 3 in 9 per cent. The number of ventrals ranges from 135 to 149, averaging 141.8.

Habits.—The northern water snake is essentially a stream species, although it can be found around lakes and ponds as well. It is active both day and night and in disposition is similar to the other large water snakes. Most specimens have been collected by raising rocks at the edge of the water and grabbing the snakes before they could escape. Their food consists primarily of fish and amphibians.

Captive females have given birth to broods of 8, 9, 11, 12, 17, and 51 young in late August and in September.

Illinois Distribution.—*N. s. sipedon* in its typical form occurs in northern Illinois: south to Champaign County in eastern Illinois and to Henderson County in the western part of the state, fig. 244. Specimens intermediate between *sipedon* and *pleuralis* occur in a broad belt extending from Champaign and Henderson counties as far south as White and Randolph counties. Specimens north of a line drawn from Charleston to Quincy, although intergrade in pattern, show a greater influence of *sipedon* and can usually be referred to the northern race.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: COOK COUNTY: West Northfield (Yarrow 1882a); Worth (Schmidt & Necker 1935); DU PAGE COUNTY: Glen Ellyn (Schmidt & Necker 1935); KNOX COUNTY: 2½ mi. E Galesburg (Adcock 1922); LAKE COUNTY: Beach (Schmidt & Necker 1935); Dead River (Necker 1939c); ST. CLAIR COUNTY: Belleville (Yarrow 1882a); Bluff Lake, Cahokia (Hurter 1893); WILL COUNTY: Wheatland Township (Necker 1939c).

Natrix sipedon pleuralis Cope
Midland Water Snake

Natrix fasciata pleuralis Cope 1892:672 (type locality: probably Summerville, South Carolina).

Natrix sipedon pleuralis, Clay 1938:178.

Nerodia sipedon, Kennicott 1855:592 (part).

Tropidonotus sipedon sipedon nec Linnaeus, Yarrow 1882a:13+5.

Nerodia sipedon sipedon nec Linnaeus, H. Garman 1892:269-72.

Natrix sipedon, Hurter 1897:500 (1).

Natrix fasciata sipedon nec Linnaeus, Cope 1900:971-2 (1).

Natrix sipedon sipedon nec Linnaeus, Blanchard 1924b:539.

Tropidonotus sipedon woodhousei, Cope 1877:64 (1).

Natrix sipedon woodhousei, Jordan 1888:194.

†*Tropidonotus fasciatus* nec Linnaeus, Davis & Rice 1883a:31.

Nerodia sipedon fasciatus nec Linnaeus, H. Garman 1892:269-71.

Natrix fasciatus nec Linnaeus, Gaige 1914:4 (1).

†*Natrix* sp., Hankinson 1910:25 (1).

Diagnosis.—A subspecies of *Natrix sipedon* (largest Illinois specimen 1,144 mm. in total length), fig. 242; similar in scutellation to *N. s. sipedon* but differing in the following details of pattern: usually less than 30

body blotches, which ordinarily consist of more than 10 transverse bands on anterior part of body and less than 20 alternating dorsal spots and lateral bars; lateral dark bars and sides of transverse bands usually much narrower than light interspaces; tail with less than 19 dark rings; ventral pattern usually with semilunar red markings, tending to form longitudinal rows.

Variation.—In addition to the dimorphism in number of caudals and in proportionate tail length (which is described under *N. s. sipedon*), the greater length of the tail in males of *N. s. pleuralis* is reflected by the number of dark tail rings. Ten males at hand exhibit a range of 15 to 18 tail rings, averaging 17; 15 females show a range of 11 to 17, averaging 14.4.

Ontogenetic variation of *N. s. pleuralis* is similar to that found in *N. s. sipedon*. Old



Fig. 242.—An adult *Natrix sipedon pleuralis* from Union County, Illinois. The groundcolor is light gray or tan; the bands and blotches are rich red-brown. The underside is conspicuously spotted with red semilunar markings.

individuals of *pleuralis* seldom show the dark stippling and general suffusion of dark pigment which characterizes very large specimens of the subspecies *sipedon*.

Geographic variation is not well marked in Illinois *pleuralis*, inasmuch as the range of the race in its typical form occupies only a little more than a dozen counties. The number of dorsal body blotches ranges from 22 to 28, averaging 24.7. The number of transverse bands on the anterior portion of the body ranges from 6 to 25, averaging 15.1. The lateral bars are definitely narrower than the light interspaces in 96 per cent of the 25 specimens at hand and equal to the interspace width in 4 per cent.

Individual variation in scutellation has been summarized for both *N. s. sipedon* and *N. s. pleuralis* under the account for the subspecies *sipedon*.

Occasional specimens from the southern counties of Illinois are peculiar in appearance because of the extremely narrow transverse bands. Many of these ringed snakes, even as juveniles, have a brownish groundcolor rather than the light gray or white characteristic of baby *N. s. sipedon*. These differences suggest influence of *N. s. confluens*. It is not difficult to derive the *confluens*-type pattern from *pleuralis*-type by envisioning fusion of pairs of dark rings and a general darkening of the groundcolor. Nevertheless, no specimens have been examined which are not clearly referable to either *pleuralis* or *confluens*.

Habits.—The habits of this water snake are very similar to those of *N. s. sipedon*, although *pleuralis* in Illinois shows a more marked preference for swift-running streams.

Brood counts of 50, 32, and 13 young are available for southern Illinois females of *pleuralis*. The average brood size is much smaller. Young are born in August and September. A female captured July 2 contained 10 small, living embryos and three large, dead young. The dead young were somewhat calcified, evidently having been retained by the mother from the previous season.

Illinois Distribution.—The range of typical *pleuralis* in Illinois consists of those counties south of Randolph and White counties, excluding the floodplain swamps of Union and Alexander counties, fig. 244. Although primarily a stream snake, *pleu-*

ralis occurs occasionally in lakes and ponds. Specimens have not been found in the Austroriparian swamps.

Although undocumented by specimens, a published record for the following additional locality is believed valid and is indicated on the distributional map by a hollow symbol: WABASH COUNTY: Mount Carmel (Cope 1877).

Natrix sipedon confluens Blanchard Broad-Banded Water Snake

Natrix fasciata confluens Blanchard 1923b:1
(type locality: Butler County, Missouri).

Natrix sipedon confluens, Necker 1934:129.

?*Natrix fasciata nec* Linnaeus, Hurter 1911:
154.

?*Natrix sipedon fasciata nec* Linnaeus, Löding
1922:35.

Diagnosis.—Presumably a subspecies of *Natrix sipedon* (largest Illinois specimen 931 mm. in total length), fig. 243; similar in scutellation to other races of *N. sipedon* but differing markedly in pattern and color as follows: a light wedge-shaped mark on each side of the head extending from the sides of the parietals diagonally to the throat; groundcolor yellowish, with 14 to 26 wide, black or chestnut-brown dorsal blotches, separated by narrow yellow interspaces; 21 to 35 lateral bars of black or brown extending from the ventrals to the dorsal blotches; venter yellow, heavily checkered with black or brown squares or rectangular blotches.



Fig. 243.—A juvenile *Natrix sipedon confluens* from Alexander County, Illinois. The groundcolor is yellow, suffused with brown or black; the bands are black or brown.

Table 85.—Sexual variation in Illinois *Natrix sipedon confluens*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (9)		FEMALES (11)	
	Range	Mean	Range	Mean
Caudals.	69-78	72.3	60-66	62.5
Tail length as percentage of total length.	22.6-27.4	25.1	20.5-24.4	22.8

Variation.—Males in this subspecies have longer tails and greater numbers of caudals than females, table 85.

The juveniles are more distinctly banded than the adults, and the groundcolor is usually clear yellow or tan, lacking the dusky suffusion of large specimens.

Individual variation in scutellation of 21 specimens from a single Illinois locality is slight. Ventrals range from 133 to 143, averaging 138.4; supralabials 8 + 8 in 80 per cent of specimens, 8 + 9 in 15 per cent, 9 + 9 in 5 per cent; infralabials 9 + 10 in 10 per cent, 10 + 10 in 65 per cent, 10 + 11 in 20 per cent, 11 + 11 in 5 per cent; preoculars 1 + 1 in 95 per cent, 1 + 2 in 5 per cent; postoculars 2 + 2 in 15 per cent, 2 + 3 in 35 per cent, 3 + 3 in 50 per cent.

In this series the pattern is more variable than the scutellation. The number of dorsal blotches ranges from 14 to 26, averaging 18.3. The number of dark lateral bands per side ranges from 20 to 35, averaging 25.1. The ventral pattern varies from a predominantly black venter to a yellow venter with scattered black or brown squares.

This series is somewhat atypical because of the high blotch count, and it is, in fact, intermediate in this character between *confluens* and Gulf Coast *fasciata*. Specimens with high blotch counts tend to have better-defined lateral bands; and, although these may be interpreted as expressions of slight *pleuralis* influence, the Illinois specimens are actually almost identical with coastal *fasciata*. They are best regarded as *confluens*, however, since *fasciata* is restricted to the Gulf region between the Mississippi River and peninsular Florida. All 21 specimens possess the head markings characteristic of both *confluens* and *fasciata* but not characteristic of other Illinois races of *N. sipedon*.

Habits.—The broad-banded water snake, unlike *N. s. sipedon* and *N. s. pleuralis*, occurs in lakes and cypress swamps and is, in

fact, the only *sipedon* representative in this type of habitat. Otherwise, it is similar in habits to the other subspecies.

A female from Horseshoe Lake, Alexander County, contained 13 full-sized embryos.

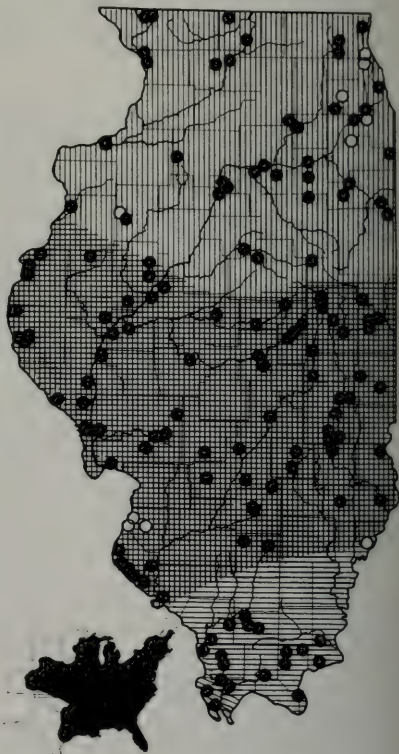


Fig. 244.—Distribution of *Natrix sipedon*. Vertical hatching indicates the presumed range of the subspecies *sipedon* in Illinois; horizontal hatching, the presumed range of the subspecies *pleuralis*; diagonal hatching, the presumed range of the subspecies *confluens*; crosshatching, the area of intergradation between *sipedon* and *pleuralis*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Illinois Distribution.—This brightly marked banded water snake is known in Illinois only from the vicinity of Horseshoe Lake, Alexander County, and it is decidedly uncommon, fig. 244. Field work in similar habitats elsewhere on the Mississippi floodplain in Alexander and Union counties has not revealed other populations. In fact, no specimens of the *N. sipedon* group have been found in these localities.

CROTALIDAE

Pit vipers are found in the New World, Asia, and eastern Europe. Three genera are known in the United States, and all are represented in Illinois. The pit vipers are regarded by some authors as a subfamily of the Viperidae.

Agkistrodon Beauvois

Two polytypic species of *Agkistrodon* occur in the United States and in Illinois. The distribution of the genus is similar to that of the family Crotalidae.

Agkistrodon piscivorus leucostomus (Troost)

Western Cottonmouth Water Moccasin

Acontias leucostoma Troost 1836:176 (type locality: western Tennessee; revised to 10 mi. NE of Bolivar, Hardeman County, by Schmidt 1953).

Agkistrodon piscivorus leucostoma, Gloyd & Conant 1943:164-5.

Ancistrodon piscivorus leucostoma, Schmidt 1953:225.

Agkistrodon piscivorus leucostomus, Smith & Taylor 1945:178.

Ancistrodon piscivorus, Cope 1877:64.

Ancistrodon piscivorus piscivorus nec Lacépède, Yarrow 1882a:79.

Agkistrodon piscivorus, Jordan 1888:199.

Diagnosis.—A large, very heavy-bodied snake (largest Illinois specimen 1,121 mm. in total length), fig. 245; usually with 25 anterior and 21 posterior rows of strongly keeled scales; ventrals 132 to 137; caudals 39 to 47, only the posterior third or half of which are divided; anal plate entire; head flattened, much wider than neck; top of head with 9 large symmetrical plates; pit between eye and nostril on each side of head; supralabials 7 or 8, infralabials from 9 to 12, usually 11 on a side; eye pupil elliptical; body with 12 to 18 broad, usually dim cross-bands that are narrowest at mid-back; venter heavily blotched with black; ground-color above red-brown in young, rusty brown in subadults, and dark olive in adults.

Variation.—Sexual dimorphism is not well marked in *Agkistrodon piscivorus*, and specimens can be reliably sexed only by dissection. Sixteen males range from 42 to 47 (average 44.5) in caudal counts and from 12.3 to 17.9 (average 15.2) per cent in proportionate tail length. Twelve females range from 39 to 45 (average 42.5) in caudals and



Fig. 245.—A subadult *Agkistrodon piscivorus leucostomus* from Jackson County, Illinois. The groundcolor varies from dark rusty brown to dark olive; the bands are dark brown to black.

in tail length from 12.1 to 16.5 (average 14.5) per cent of total length. Females occasionally (25 per cent in our sample) have 23 posterior rows of scales; all males in the sample at hand have 21.

Ontogenetic variation in water moccasins consists of four general color phases based on age. Individual variation is considerable in each size-class.

Baby water moccasins, in the first color phase, are conspicuously banded with wide saddles that are narrowest on the middorsum. These bands are heavily margined with black. The groundcolor is light red-brown, often with a wash of orange. Although Gloyd & Conant (1943) stated that the dull juvenile color of *A. p. leucostomus* is a diagnostic character of the subspecies, many southern Illinois juveniles are so brightly colored as to resemble copperheads. A distinct black postorbital stripe is present on each side of the head. The tip of the tail is sulfur yellow.

The second color phase includes older juveniles. These snakes differ from the newly born snakes in that the pattern details have dimmed and the bright coloration has been replaced by a dirty rusty brown ground-color. The yellow tail tip is evident ventrally only or is completely lost.

Subadults, in the third color phase, are very dark. The venter, particularly on the posterior part of the body, and the dorsal side of the tail are predominantly black. The crossbands are usually indicated by light-flecked scales that border the bands.

Large water moccasins, in the fourth color phase, are dark olive above and below and have dark crossbands. The pattern on the dorsum and venter is more pronounced in large adults than in subadults in the second and third color phases.

Individual variation in a sample of 30 snakes is as follows: ventrals 132 to 137 (average 135.2); anterior scale rows 23 in 7 per cent of specimens, 24 in 10 per cent, 25 in 24 per cent, 26 in 52 per cent, 27 in 7 per cent; scale rows at mid-body 23 in 7 per cent, 25 in 90 per cent, 26 in 3 per cent; posterior scale rows 19 in 4 per cent, 21 in 86 per cent, 23 in 10 per cent; supralabials 8 + 8 in 86 per cent, 7 + 7 in 10 per cent, 7 + 8 in 4 per cent; infralabials 11 + 11 in 69 per cent, 10 + 10 in 14 per cent, 11 + 12 in 10 per cent, 10 + 11 in 3.5 per cent, 9 + 11 in 3.5 per cent; body crossbands 12

to 18 (average 13.3). The mean number of caudals for both sexes is 43.5. The number of entire caudals ranges from 8 to 36, averaging 24.8.

Habits.—In the summer months, this ugly, ill-tempered snake frequents sloughs and swamps and in the fall migrates to rock bluffs, where it hibernates in fissures in the rocks along with rattlesnakes and black snakes. Occasionally the water moccasin is encountered during the day, but it is essentially nocturnal. In the wild the moccasin will sometimes run if found near vegetation or water, but if met in the open it usually draws its head back and opens its mouth in threatening behavior. If further annoyed the heavy tail is vibrated and the snake coils to strike, continuing to expose the inside of its mouth. Although recent deaths in Illinois due to the bite of the moccasin are unknown, the bite is serious, and care should be taken to avoid this snake. The cottonmouth feeds on a variety of animals, including snails, fish, amphibians, snakes, and mammals. At least one instance of carrion-feeding is known. Klimstra (1959b) noted that in southern Illinois fish constitute 32 per cent of its diet, amphibians 26 per cent, reptiles 18 per cent, and mammals 18 per cent.

Captives have given birth to broods of three to five young in the laboratory during early September.

Illinois Distribution.—The cottonmouth in Illinois is restricted to the southern tip of the state, fig. 246. It is abundant on the Mississippi River floodplain and adjacent rock bluffs from Jackson County southward, but numerous visits to the counties to the north have yielded specimens from only one locality—a marsh near Fults, Monroe County. The amount of field work in Randolph County, where moccasins are expected but have not been found, strongly suggests that the Fults population may be an isolated relict. Hurter (1897) reported having seen the species opposite St. Louis. Residents in this area are not familiar with the moccasin, although they recognize copperheads and rattlesnakes. It is therefore possible that Hurter's snakes might have been a localized colony similar to that at Fults.

A parallel situation may have existed along the Wabash River, as Ridgway (Cope 1877) reported the species at Mount Carmel. Fishermen and other residents who have been questioned do not believe the cot-



Fig. 246.—Distribution of *Agkistrodon piscivorus*. Hatching indicates the presumed range of the subspecies *leucostomus* in Illinois; solid circles indicate localities represented by specimens examined during this study; the open circle indicates a locality represented by a published record believed to be valid. The lower map depicts the total range of the species in the United States.

tonmouth occurs anywhere on the Wabash River. It appears that the moccasin does not at present inhabit the Wabash Valley, as there are no recent records for Illinois or adjacent Indiana. It is more common in the southern tip than the map indicates.

Although undocumented by specimens, a published record for the following locality is believed valid and is indicated on the distribution map by a hollow symbol: WABASH COUNTY: Mount Carmel (Cope 1877).

Agkistrodon contortrix (Linnaeus)

Four North American subspecies of the copperhead are recognized. An eastern subspecies and an intergrade population combining characters of the eastern race and the nominate race occur in Illinois.

Agkistrodon contortrix mokeson (Daudin)

Northern Copperhead

Cenchrus mokeson Daudin 1803:358 (type locality: vicinity of Philadelphia, Pennsylvania).

Agkistrodon mokeson mokeson, Gloyd & Conant 1943:150-3.

Agkistrodon contortrix mokeson, Perkins 1949:24.

Agkistrodon d. mokeson, Wright & Wright 1952:585.

Ancistrodon contortrix mokeson, Schmidt 1953:224.

Agkistrodon contortrix, Brendel 1857:254.

Ancistrodon contortrix, Davis & Rice 1883a:28.

Agkistrodon contortrix, Stejneger 1895:404.

Agkistrodon contortrix contortrix, Perkins 1949:24 (1).

Agkistrodon d. contortrix, Wright & Wright 1952:585 (1).

Ancistrodon contortrix contortrix, Schmidt 1953:224 (1).

Agkistrodon mokeson, Stejneger & Barbour 1917:106-7.

Agkistrodon mokeson mokeson, Conant 1934:22.

Agkistrodon mokeson cupreus, Gloyd & Conant 1938:164-5.

Agkistrodon mokeson austrinus Gloyd & Conant 1943:153 (type locality: Gentilly, Orleans Parish, Louisiana).

Agkistrodon mokeson austrinus, Minton & Minton 1948:387.

Diagnosis.—A large, moderately heavy-bodied snake (largest Illinois specimen 1,383 mm. in total length), fig. 247, with 23 to 27 anterior and 19 or 21 posterior rows of strongly keeled scales; ventrals 147 to 155; caudals 41 to 50, the posterior fourth of which are divided; anal plate entire; head flattened, wider than neck; top of head with 9 large symmetrical plates; loreal present; pit present between eye and nostril on each side of head; supralabials 7 to 9, usually 8 per side; infralabials 8 to 11, usually 9 or 10 per side; eye pupil elliptical; groundcolor light red-brown or yellowish brown, with 11 to 18 hourglass-shaped crossbands having broad dark margins; venter light yellow-brown or red-brown, with brown blotches on the sides of ventrals; lateroventral blotches alternating with dorsal crossbands; a thin dark line on each side of head extending from eye to angle of jaws; head above this line red-brown, below yellowish white; a pair of dark parietal dots. The copperhead resembles the juvenile cottonmouth.

Variation.—In *Agkistrodon contortrix* sexual dimorphism in scutellation and proportions is slight, table 86.

Baby copperheads, like juvenile cottonmouths, have sulfur-yellow tails. As the snakes become older, the yellow is replaced by black. There is a slight tendency toward proportionately shorter tails in adult snakes, table 87.

Geographic variation in this snake is discernible only in details of color and pattern, table 88. Specimens from the Mississippi River counties show some influence of the Austroriparian race, *A. c. contortrix*, by having relatively paler hues, more con-

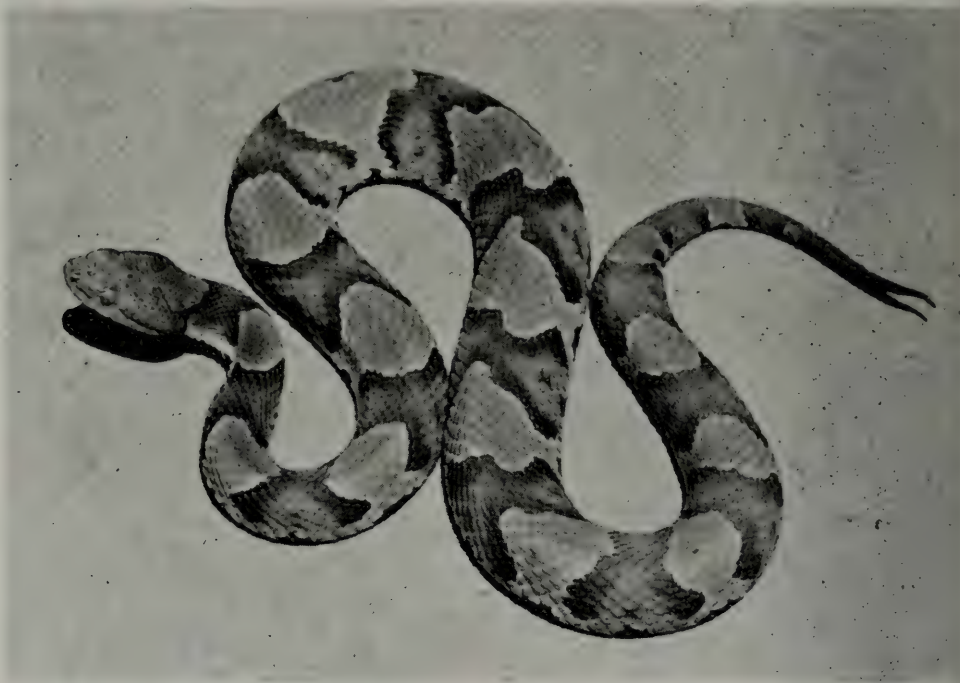


Fig. 247.—An adult *Agkistrodon contortrix mokeson* from Alexander County, Illinois. The groundcolor is tan or light red-brown; the bands are rich red-brown.

Table 86.—Sexual variation in Illinois *Agkistrodon contortrix*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (23)		FEMALES (16)	
	Range	Mean	Range	Mean
Caudals.....	41-50	46.5	41-46	44.0
Tail length as percentage of total length.....	10.1-16.7	14.4	11.2-15.1	13.6

Table 87.—Ontogenetic variation in proportionate tail length in Illinois *Agkistrodon contortrix*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	UNDER 500 MM. TOTAL LENGTH (19)		500-800 MM. TOTAL LENGTH (12)		OVER 800 MM. TOTAL LENGTH (6)	
	Range	Mean	Range	Mean	Range	Mean
Tail length as percentage of total length.	13.9-16.7	15.2	11.2-14.2	12.7	10.1-13.6	11.9

Table 88.—Geographic variation in pattern and color of Illinois *Agkistrodon contortrix*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	EAST-CENTRAL ILLINOIS (6)		SOUTHEASTERN ILLINOIS (19)		WEST-CENTRAL ILLINOIS (9)		SOUTHWESTERN ILLINOIS (18)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Per cent of crossbands complete on individual specimens.....	73.5–100.0	88.3	62.5–100.0	87.0	28.5–93.0	71.0	44.5–100.0	81.5
Average width of crossbands (expressed in scale lengths)	2.2–3.3	2.6	2.0–3.4	2.6	1.8–2.8	2.4	2.0–3.1	2.5
	PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS		PER CENT OF SPECIMENS	
With pale colors of <i>A. c. contortrix</i>	0		0		50		41	
With paired dark dorsal spots between crossbands..	100		94.5		25.0		41.0	

stricted crossbands dorsally, and a larger number of interrupted crossbands. This observation is in agreement with the findings of Gloyd & Conant (1943), although in all Illinois populations the influence of *mokeson* predominates.

Paradoxically, the sample from west-central Illinois exhibits more *contortrix* characters than the sample from extreme southwestern Illinois. This is the reverse of the expected condition, and the intergradation pattern parallels that of the *Natrix erythrogaster* races.

Individual variation in Illinois copperhead scutellation that shows no correlation with sex, age, and geography is as follows: ventrals 147 to 155 (average 150.0); body bands 11 to 18 (average 15.2); supralabials 7 + 8 in 16.5 per cent of specimens, 8 + 8 in 80.5 per cent, 8 + 9 in 3.0 per cent; infralabials 8 + 10 in 3.0 per cent, 9 + 9 in 30.5 per cent, 9 + 10 in 22.0 per cent, 9 + 11 in 5.5 per cent, 10 + 10 in 30.5 per cent, 10 + 11 in 8.5 per cent; anterior scale rows 23 in 5.0 per cent, 24 in 40.0 per cent, 25 in 25.0 per cent, 26 in 12.5 per cent, 27 in 15.0 per cent, 28 in 2.5 per cent; scale rows at mid-body 23 in 92.0 per cent, 24 in 5.5 per cent, 25 in 2.5 per cent; posterior scale rows 18 in 5.5 per cent, 19 in 73.0 per cent, 20 in 2.5 per cent, 21 in 19.0 per cent.

In general those Illinois copperheads with darker markings tend to have less con-

stricted dorsal crossbands and to have varying amounts of dusky stippling on the venter. The presence of paired dark spots between the crossbands is probably also correlated with the prominence of the crossbands. The last-named feature has not been noted in published descriptions of copperheads insofar as I am aware.

Habits.—The richly colored copperhead inhabits wooded hillsides or bluffs, particularly those with rock outcrops. The species is active both at night and during the day. In spring and fall it may be numerous in talus slides at the foot of rock bluffs. During summer it is occasionally seen in meadows and fields. Abandoned sawmills and dilapidated buildings are particularly attractive to the copperhead, probably because of the usual presence of mice at such sites. The copperhead usually attempts to escape by running. When cornered it draws back its head and vibrates the tip of its tail. Although no deaths in Illinois are known from copperhead bites, the species is dangerous. The food consists of small mammals, birds, frogs, and some insects.

Captive females have given birth to broods of 3, 4, 5, 8, and 11 young. The earliest date of birth is July 30; the latest date September 10.

Illinois Distribution.—Copperheads occur in the southern third of Illinois, fig. 248, and they are moderately common in the

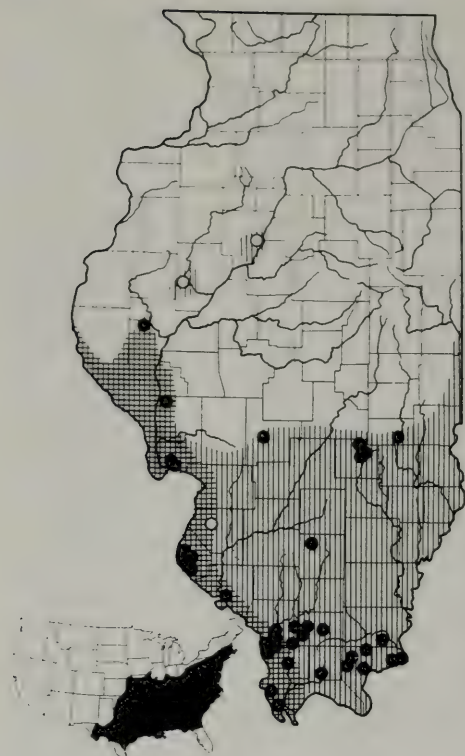


Fig. 248.—Distribution of *Agkistrodon contortrix*. Vertical hatching indicates the presumed range of the subspecies *mokeson* in Illinois; crosshatching, the area of intergradation between the subspecies *mokeson* and *contortrix*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

Shawnee Hills and along the Mississippi River bluffs north to the mouth of the Illinois River. The region north of the Shawnee Hills and east of the Mississippi is probably occupied by a very few scattered relict colonies. The requisite wooded, rocky hillsides are sparse in this region, and even in those few local habitats which still appear suitable for *Agkistrodon*, copperheads may have been either completely exterminated or greatly reduced in numbers.

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: FULTON COUNTY: (Necker 1939*b*); PEORIA COUNTY: Peoria (H. Garman 1892); ST. CLAIR COUNTY: (Hurter 1911).

Sistrurus Garman

Two species of *Sistrurus*, each with several subspecies, occur in the United States and Canada. The genus is confined to North America. One form occurs in Illinois.

Sistrurus catenatus catenatus (Rafinesque)

Eastern Massasauga Swamp Rattlesnake

Crotalinus catenatus Rafinesque 1818:41 (type locality: prairies of upper Missouri; revised to vicinity of Kansas City, Missouri, by Schmidt 1953).

Sistrurus catenatus, Hay 1891:109.

Crotalophorus catenatus, Hay 1892*b*:387.

Sistrurus catenatus catenatus, Cope 1900:1149.

Crotalophorus kirtlandii, Kennicott 1855:592.

Crotalophorus tergeminus nec Say, Baird 1854*b*:108.

Caudisona tergemina nec Say, Davis & Rice 1883*a*:28.

Diagnosis.—A moderate-sized, stout-bodied rattlesnake (largest Illinois specimen 885 mm. in total length), fig. 249, with 24 to 27 anterior and 18 or 19 posterior rows of strongly keeled scales; ventrals 138 to 151; caudals 22 to 31, the last few of which may be divided; a rattle or, in juvenile, a large "button" on tip of tail; supralabials 11 to 13 per side; infralabials 12 to 14 per side; top of head with 9 enlarged symmetrical plates; a pit present between eye and nostril on each side of head; groundcolor above gray or light brown, with 29 to 40 middorsal light-edged, dark, round, or concave blotches; each side of body with 2 or 3 rows of alternating round dark spots; tail with 4 to 7 dark rings; venter heavily mottled with black; narrow but distinct light stripe extending from pit to angle of jaws on each side of head; top of head with a pair of dark bars extending from the parietal onto the neck.

Variation.—Sexual variation in this snake is not pronounced but it is illustrated in several characters, table 89.

The juvenile massasauga differs from the adult in having a paler groundcolor, more distinct pattern, yellow on tip of tail, and a "button" rather than a rattle. The ventral mottling is also more discrete in young massasaugas than in adults, many of which are almost black beneath.

Adequate samples of this snake are not available to discern definite trends in geographic variation, although a blotch count



Fig. 249.—An adult *Sistrurus catenatus catenatus* from Piatt County, Illinois. The ground-color is gray, tan, or light brown; the blotches are dark gray or dark brown.

Table 89.—Sexual variation in Illinois *Sistrurus catenatus catenatus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (8)		FEMALES (10)	
	Range	Mean	Range	Mean
Ventrals.....	138-145	140.8	138-151	143.4
Caudals.....	27-31	29.0	22-29	24.2
Body blotches.....	30-35	32.3	29-40	33.6
Tail rings.....	5-7	6.2	4-6	5.0
Tail length as percentage of total length.....	8.0-9.8	9.2	5.6-10.2	7.5

gradient from north to south is suggested when the average number of dorsal blotches of specimens from central Illinois is compared with that of specimens from southwestern Illinois. Fifteen specimens from the central part of the state have 23 to 40 (average 32.3) dorsal blotches; seven specimens from Madison and Fayette counties have 26 to 34 (average 29.5).

Individual variation in a sample of 18 specimens is as follows: anterior scale rows 25 in 29 per cent of specimens, 26 in 29 per cent, 27 in 35 per cent, and 28 in 6 per cent; scale rows at mid-body are 24 in 12 per cent, 25 in 70 per cent, 26 in 12 per cent, and 27 in 6 per cent; posterior scale rows are 18 in 18 per cent, 19 in 82 per cent. Some variation in darkness of groundcolor is apparent, but, in the course of this study, no melanistic specimens have been found. Kennicott (1855), however, mentions a black example from Cook County.

Habits.—Although this small rattlesnake occurs in bogs and other wooded areas, the preferred habitat is probably prairie marshes or old fields with heavy bluegrass cover. Specimens are occasionally found under objects such as logs or grain shocks, but most individuals are encountered sunning themselves on clumps of grass or crossing roads. Several of these snakes have been caught in snap traps set in mice runs in a prairie near Monticello. Wild specimens usually are retiring; a cornered individual may throw its body into coils and vibrate its rattle. A few persons in Illinois are known to have been bitten by massasaugas; although hospitalization was required for the bitten persons, they were not in serious danger. Small mammals appear to be the most important food item of massasaugas; birds are probably other items in the diet. A captive massasauga fed on small snakes, frogs, and mice.

According to Wright (1941) the brood size in northern Illinois ranges from 5 to 14, and the young are born in late August and early September.

Illinois Distribution.—The massasauga presumably was common over the northern four-fifths of Illinois before intensive cultivation and drainage of prairie marshes. The species now occurs in widely scattered colonies, fig. 250, where the land is too marshy for cultivation or where, for various reasons, agricultural practices have diminished.

Although undocumented by specimens, published records for the following localities are believed valid; most are indicated on the distribution map by hollow symbols: CLARK COUNTY: near Casey (P. W. Smith 1947); COLES COUNTY: Charleston (Hankinson 1917); COOK COUNTY: Palos Park (Pope 1944b); Wheeling (Schmidt & Necker

1935); EDGAR COUNTY: Paris (Hay 1892b); JACKSON COUNTY: Murphysboro (Gloyd 1940); KNOX COUNTY: Galesburg (H. Garman 1892); LAKE COUNTY: Deerfield (Schmidt & Necker 1935); McLEAN COUNTY: Normal (H. Garman 1892); PEORIA COUNTY: Peoria (H. Garman 1892); WILL COUNTY: Crete (Stille & Edgren 1948); between Crete and Goodenow (Pope 1944b).

Crotalus Linnaeus

Thirteen species of this North and South American genus occur within the continental United States. Most of the species have two or more subspecies.

Crotalus horridus Linnaeus

Two subspecies of timber rattlesnake are known. The nominate race and an intergrade population that exhibits characters of the Gulf Coastal race occur in Illinois.

Crotalus horridus horridus Linnaeus Timber Rattlesnake

Crotalus horridus Linnaeus 1758:214 (type locality: America; revised to vicinity of New York City by Schmidt 1953); Davis & Rice 1883a:28.

Crotalus horridus horridus, Klauber 1936:246.

Crotalus horridus atricaudatus, Pope 1937:224.

Crotalus horridus horridus × *atricaudatus*, Necker 1939b:39.

Crotalus cyanurus, Rafinesque 1820:5.

Crotalus duressus nec Linnaeus, Kennicott 1855:592.

Crotalus durissus nec Linnaeus, Brendel 1857:254.

Diagnosis.—A large, stout-bodied snake (largest Illinois specimen 1,524 mm. in total length), fig. 251, with 21 to 27 anterior and 19 to 21 posterior rows of strongly keeled scales; ventrals 162 to 178; caudals 19 to 30, the last 1 or 2 of which may be divided; tip of tail with rattle or enlarged "button"; supralabials 12 to 16 per side; infralabials 13 to 18 per side; top of head covered with small asymmetrical scales and two enlarged plates; pit present between eye and nostril on each side of head; groundcolor gray, light yellow, or greenish white above, with 20 to 26 black dorsal blotches or angular rings; tail usually uniform black; venter gray, white, or yellow, with blotching and stippling present on sides of ventral plates; a mid-dorsal rust-colored stripe occupying 2 to 5 scale widths on the anterior part of the



Fig. 250.—Distribution of *Sistrurus catenatus*. Hatching indicates the presumed range of the subspecies *catenatus* in Illinois; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.



Fig. 251.—An adult *Crotalus horridus horridus* × *atricaudatus* intergrade from Jackson County, Illinois. The groundcolor may be pale gray, greenish white, or yellowish white; the bands are sooty black; a vague, middorsal rust-colored stripe is present on the anterior part of the body.

Table 90.—Sexual variation in Illinois *Crotalus horridus*. Figures in parentheses are numbers of specimens.

CHARACTERISTIC	MALES (14)		FEMALES (15)	
	Range	Mean	Range	Mean
Ventrals.....	162-174	168.5	163-178	170.0
Caudals.....	21-30	26.0	19-23	20.7
Tail length as percentage of total length.....	5.4-9.6	7.4	5.1-8.0	6.3

body; a dark postorbital bar usually present on each side of head.

Variation.—The male of the timber rattlesnake has a slightly lower ventral count average than the female, table 90.

The juvenile differs from the adult most markedly in the presence of a terminal “button” rather than a rattle and in having a lighter groundcolor. Tail rings are sometimes visible on young snakes; the tails of subadults and adults are uniform black.

On the basis of the number of scale rows at mid-body and average adult size, the rattlesnakes of extreme southwestern Illinois are referable to the Coastal Plain race, *Crotalus horridus atricaudatus*, table 91. In ventral count averages and most details of pattern these snakes resemble the more northern specimens. Specimens from the Mississippi River counties of Illinois from Jackson County southward are therefore regarded as *C. h. horridus* × *atricaudatus*.

Table 91.—Geographic variation in Illinois *Crotalus horridus*. Figures in parentheses are numbers of specimens.

NUMBER OF SCALE ROWS AT MID-BODY	ALEXANDER- PERRY COUNTIES (12)	MONROE-PIKE COUNTIES (8)	ROCK ISLAND- JO DAVIESS COUNTIES (5)	COLES-JASPER COUNTIES (4)
With 21 rows (per cent of specimens).....	0	0	0	25
With 23 rows (per cent of specimens).....	33	76	80	25
With 24 rows (per cent of specimens).....	25	12	0	25
With 25 rows (per cent of specimens).....	42	12	20	25

intergrades. This disposition of Illinois specimens is in complete agreement with the range definition of the two races as pointed out by Gloyd (1940).

Other variation in a sample of 30 timber rattlesnakes from various parts of Illinois is apparently individual. There is some evidence that snakes in one colony may differ from those in another colony in minor details of pattern. This variation among colonies is not clear-cut and may be fortuitous. Anterior scale rows in the 30 snakes mentioned above are as follows: 24 in 13 per cent of sample, 25 in 17 per cent, 26 in 50 per cent, and 27 in 20 per cent; posterior scale rows 18 in 3 per cent, 19 in 74 per cent, 20 in 20 per cent, and 21 in 3 per cent. Supralabials are highly variable; they range from 12 to 16 per side; 13 or 14 occur most frequently. Infralabials range from 13 to 18, 14 or 15 occurring most frequently. The number of body bands ranges from 20 to 26, averaging 23.6. A dark postorbital stripe on each side of the head is present in most snakes; it is dim in occasional specimens, particularly in those from northwestern and eastern Illinois. Light-centered lateral spots on anterior portion of body and black spots or dashes between the bands occur on nearly all the Illinois timber rattlers.

The black phase, which occurs in more eastern populations of timber rattlesnakes, has not been encountered in this state, and only one of the Illinois specimens (INHS 1548 from Greene County) has the decidedly yellow groundcolor of eastern snakes. Most Illinois specimens of *C. horridus* are light gray, with sooty black bands.

Habits.—This large rattlesnake is usually found in areas where there are forested bluffs and rock outcrops. It is active day

and night. During the summer months, it may be found in upland forests or even in cultivated fields. Abandoned buildings, old sawmills, and brush piles are especially at-



Fig. 252.—Distribution of *Crotalus horridus*. Vertical hatching indicates the presumed range of the subspecies *horridus* in Illinois; cross-hatching, the area of intergradation between the subspecies *horridus* and *atracaudatus*; solid circles indicate localities represented by specimens examined during this study; open circles, localities represented by published records believed to be valid. The lower map depicts the total range of the species in the United States.

tractive places, probably because of the small mammals to be found in such sites. In the fall the timber rattler congregates at den sites, which are usually rock bluffs with many deep cracks and fissures. The species is not aggressive, but in the wild it usually does not try to run. Once disturbed it coils quickly, sounds its rattle, and prepares to strike. The bite of the timber rattlesnake is serious, and deaths of human beings have been caused by Illinois snakes of this species. The food of this snake apparently consists almost exclusively of mammals and birds.

Captive females of this species have given birth to broods of eight and nine young in late August.

Illinois Distribution.—The timber rattlesnake still occurs in all the Mississippi River counties of Illinois in which the river bluffs have not been denuded of forest. The species is fairly common in a few areas along the Mississippi River where rock outcrops are extensive. It occurs in widely scattered colonies in Illinois south of the Shelbyville Moraine, fig. 252, but it has become so rare in this part of the state that the killing of a rattlesnake is usually recorded in the local

newspapers. The timber rattler formerly occurred in bluffs up the Illinois River to at least La Salle County. J. F. Toedte of Chicago possesses a snapshot of a large *C. horridus* killed near Bailey Falls about 1924. However, the occurrence of the species in the Chicago area within historic times is highly questionable, despite the statement "rare in Cook County" made by Kennicott (1855).

Although undocumented by specimens, published records for the following localities are believed valid and are indicated on the distribution map by hollow symbols: ADAMS COUNTY: Quincy (Gloyd 1940); COLES COUNTY: 3 mi. E Charleston (Hankinson 1917); FULTON COUNTY: (Necker 1939*b*); HANCOCK COUNTY: Augusta (Necker 1939*b*); Warsaw (Gloyd 1940); JEFFERSON COUNTY: Mount Vernon (H. Garman 1892); LA SALLE COUNTY: Bailey Falls (J. F. Toedte, personal communication); PEORIA COUNTY: Peoria (H. Garman 1892); PULASKI COUNTY: (Necker 1939*b*); RANDOLPH COUNTY: (Necker 1939*b*); ST. CLAIR COUNTY: Falling Springs (Hurter 1911); WABASH COUNTY: (H. Garman 1892).

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The following index to scientific names includes synonyms as well as currently valid names. Synonymic names and combinations, variant spellings, and names of extralimital forms have page references in lightface; the currently valid name for each taxon that occurs in Illinois is recognizable because one page reference, that indicating where the taxon is discussed, is in boldface. For convenience in indexing, specific and subspecific names are given equal rank. Thus, a reference for the Illinois form *Bufo woodhousei foxleri* will be found under *Bufo foxleri*; *foxleri*, *Bufo*; *Bufo woodhousei*; and *woodhousei*, *Bufo*. The boldface reference will be found under *Bufo foxleri* and *foxleri*, *Bufo*, but not under *Bufo woodhousei* or *woodhousei*, *Bufo*, inasmuch as the nominate subspecies (*woodhousei*), which does not occur in Illinois, is not discussed in detail. Hybrids and intergrade populations are written in the conventional fashion with X to denote the relationship. The name of the parent population whose phenotypic influence predominates appears first. Individuals and populations of mixed parentage are regarded as genetically distinct from both parental taxa.

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ILLINOIS NATURAL HISTORY SURVEY
Bulletin

*Printed by Authority of
the State of Illinois*



The Fishes of
Champaign County, Illinois,
as Affected by 60 Years
of Stream Changes

R. WELDON LARIMORE
PHILIP W. SMITH

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
NATURAL HISTORY SURVEY DIVISION
Urbana, Illinois

ILLINOIS NATURAL HISTORY SURVEY
Bulletin

Volume 28, Article 2
March, 1963



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This paper is a joint contribution from two sections of the Illinois Natural History Survey: the Section of Aquatic Biology, represented by Dr. R. Weldon Larimore, Aquatic Biologist, and the Section of Faunistic Surveys and Insect Identification, represented by Dr. Philip W. Smith, Associate Taxonomist.

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Wildcat Slough, a tributary of the Sangamon River, south of Fisher. The lower part of this stream is typical of the undredged creek in Cham-paign County; it contains a great variety of fishes.

The Fishes of Champaign County, Illinois, as Affected by 60 Years of Stream Changes

R. WELDON LARIMORE

PHILIP W. SMITH

THE FISHES OF CHAMPAIGN COUNTY, Illinois, have received probably as intensive and prolonged study as those in any area of equal size in the New World. The long period of observation has furnished an unusual opportunity to evaluate the ecological changes that have occurred in a highly developed agricultural and urban region and to relate these changes to the distribution and abundance of stream fishes.

In 1899 and several years before and after, Stephen A. Forbes and Robert E. Richardson made 48 collections of fishes in Champaign County while gathering material for their study *The Fishes of Illinois* (Forbes & Richardson 1908). Their collections included approximately 65 species. In 1928 and 1929, David H. Thompson and Francis D. Hunt made 132 Champaign County collections that included approximately 75 species (Thompson & Hunt 1930). The exact number of species in these early studies is uncertain because some of the reported species were composites of two or more currently recognized species. Thompson & Hunt's study was aimed at discerning distributional changes in fish. The use of standardized sampling methods and a systematic approach to making collections enabled them to express results quantitatively (to include numbers and weights of fish) as well as qualitatively (to include only names of species) and permitted them to make a number of important generalizations regarding the distribution and abundance of fishes in small streams.

A period of about 30 years elapsed between the study by Forbes & Richardson and that by Thompson & Hunt. As a second 30-year period drew to a close, a unique opportunity to collect data that could be compared with those of Forbes & Richardson and Thompson & Hunt, and to test some of the concepts outlined by Thompson & Hunt, could not be ignored. Accordingly, we undertook a third survey

in the summer of 1959 and the spring of 1960. Our investigation was similar to that of Thompson & Hunt, except that, in order to obtain more standardized data, we utilized techniques and refinements unknown in 1928 and 1929. The present paper is the result of the third survey.

Throughout this study, emphasis has been placed on changes—changes in the county resulting from agricultural development and population increase, changes in the streams resulting from natural and human modifications, changes in aquatic habitats resulting from new developments in land use practices, and changes in the fishes as these adaptable animals adjusted to new conditions in their naturally unstable aquatic environment.

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For kindly answering our questions concerning the 1928 survey and giving his opinion on some of the recent collections, we particularly thank Dr. David H. Thompson. For graciously transcribing his records and field notes on angling in Champaign County, we are grateful to Dr. Marcus S. Goldman.

Dr. Milton B. Trautman and Dr. Reeve M. Bailey checked the identifica-

tion of some of the difficult specimens. Dr. Horace W. Norton and Mr. Bud J. Meador gave counsel and guidance in analyzing our data. Dr. Thurston E. Larson, Dr. Russell T. Odell, Dr. Robert A. Evers, and Mr. W. J. Roberts offered detailed information relating to their particular specialties.

The photographs were taken by Mr. William E. Clark and Mr. Wilmer D. Zehr; fig. 6 was drafted by Mrs. Alice Ann Prickett; much of the drafting of the distribution on maps was done by Mr. Ralph G. Downer.

We owe a special debt to Dr. George W. Bennett for suggestions and encouragement throughout the investigation and to Dr. Bennett and Dr. H. H. Ross for critical perusal of our early manuscript. We are indebted to Mr. James S. Ayars for his editing of the final manuscript.

The Illinois State Department of Conservation co-operated in this study by supporting part of the field work and laboratory analyses.

METHODS AND EQUIPMENT

Methods and equipment employed in sampling stream fish populations should be selected on the basis of the demands and objectives of the study and the amount of time and effort that can be expended in making the collections. During each of the surveys of the fishes of Champaign County, the procedure was to visit well-distributed sites, selected to yield a comprehensive picture of the fishes of the streams. Seines were used as standard equipment in the first two investigations; during the third survey both seines and electrofishing equipment were employed. The total time spent procuring collections may have doubled with each succeeding survey. These changes in procedure and intensity of collecting present difficulties in comparing results of the three surveys. In drawing conclusions, we have carefully weighed the difficulties inherent in a study extending over more than half a century.

Forbes & Richardson Procedure

Forbes & Richardson (1908) made their collections by seining, presumably with seines of various mesh sizes, at selected sites throughout the county. As far

as we know, these early investigators made no attempt to do a uniform amount of seining at each station or to determine the relative abundance of the various species found. The number of revisits, if any that they made to their stations cannot be ascertained. According to Thompson & Hunt (1930:16), the collections of Forbes & Richardson spanned a 20-year period: 1 in 1882, 3 in 1885, 1 in 1892, 2 in 1898, 22 in 1899, 3 in 1900, and 8 in 1901, giving a total of 40 collections from 40 stations. Apparently these counts were made from the old accession catalogs and the atlas of maps that accompanied Forbes & Richardson's *The Fishes of Illinois*. They do not agree with our calculations. Our count of localities plotted by Forbes (1907) and by Forbes & Richardson (1908) and of localities represented by specimens still extant at the Natural History Survey from early collections raises the number of Champaign County localities sampled by Forbes & Richardson to 48, distributed by drainages as follows: Salt Fork 27, Sangamon 10, Kaskaskia 5, Embarrass 3, and Middle Fork 3.

Thompson & Hunt Procedure

Thompson & Hunt (1930:14-7) employed seines of certain lengths and mesh sizes. They recorded the actual number of fish taken at each collecting station and the calculated number per 100 square yards of area seined. In the words of Thompson & Hunt (1930:5), "the general methods employed in the former survey have been applied intensively to a small area, Champaign County, and use has been made of special methods which yield results more strictly quantitative." Records show that 126 stations were sampled in 1928 and that a few stations were revisited in the spring of 1929. Of the total number of collections, 132, Thompson & Hunt (1930:14-7) made 127 with a seine, 10 feet by 4 feet, having meshes one-sixth inch square and 5 with a seine, 75 feet by 6 feet, having meshes 1 inch square. Their 126 stations were distributed by drainages as follows: Salt Fork 48, Sangamon 31, Embarrass 19, Kaskaskia 15, Middle Fork 9, and Little Vermilion 4. Thompson & Hunt emphasized, and demonstrated with amazing success, the importance of skill and efficiency in

sampling with seines. The distribution of the Forbes & Richardson and the Thompson & Hunt collecting stations is depicted in fig. 1.

1959 Survey Procedure

The intention, when our survey was being planned, was to duplicate the seining

procedures employed by Thompson & Hunt and in addition to extend the sampling at each station by using more efficient, recently developed methods that would lead to quantitative samples of greater reliability. We soon realized, however, that it would be virtually impossible to duplicate their seining proce-

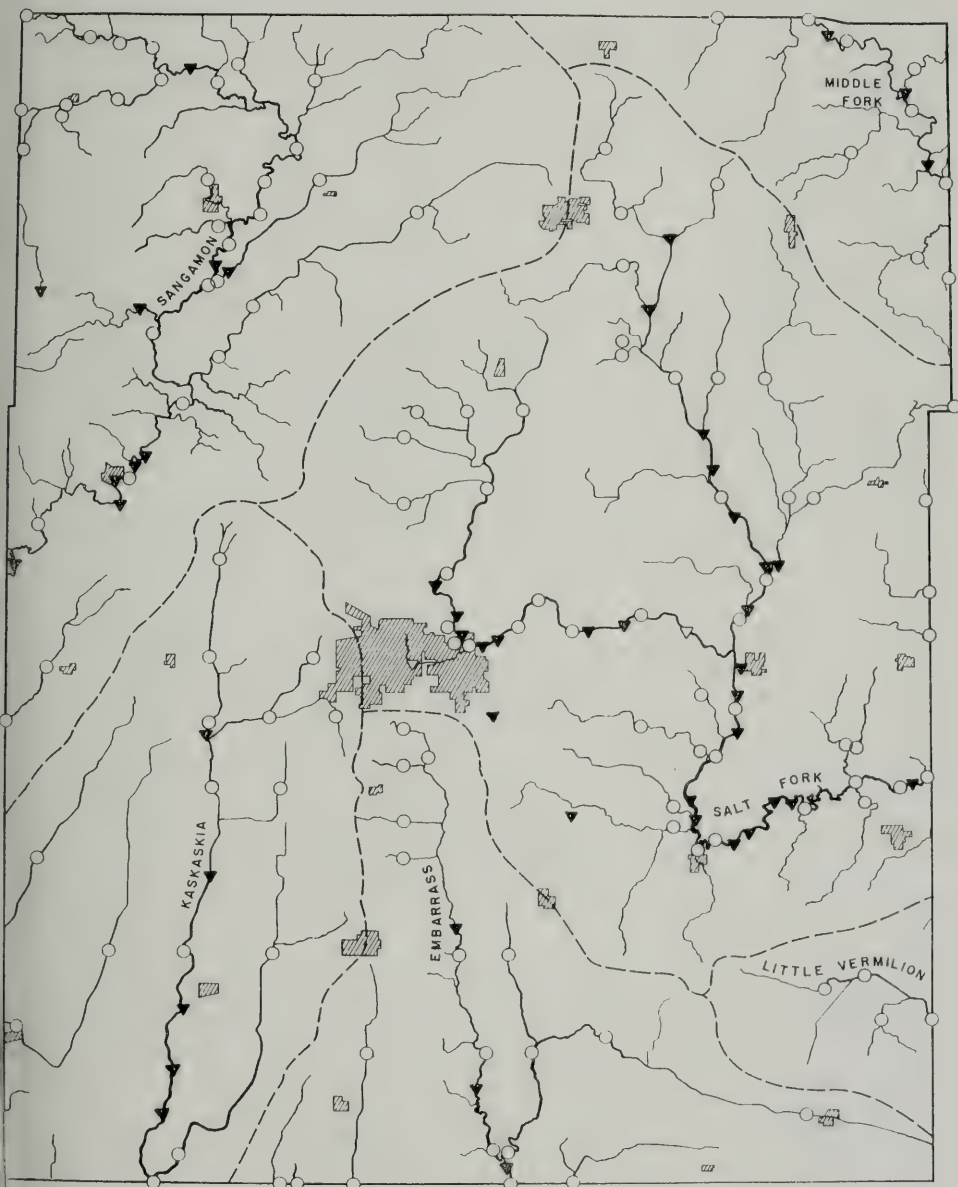


Fig. 1.—Distribution of the Forbes & Richardson (inverted solid triangles) and of the Thompson & Hunt (open circles) collecting stations in Champaign County. The hatched area near the center of the map represents Champaign-Urbana.



Fig. 2.—Seining a shallow, rocky riffle in the Sangamon River near Mahomet. Agitation upstream from the seine dislodges darters, madtoms, and certain minnows from the gravel.

dures, and that even a slight change in technique could strongly influence any quantitative value of the sample. We therefore chose a standard procedure of blocking off a section of stream and collecting the fishes within the section with an electric fish shocker. In efforts to extend our list of species in the area, we then seined various habitats close to the blocked-off section.

Selection of Site.—Because of the uneven distribution of fishes in a stream, the selection of a sampling station was of considerable importance. Inasmuch as Thompson & Hunt had mapped the location of each of their sites before going into the field, and their maps, on file at the Natural History Survey, were available to us, we chose to revisit their stations. However, we did not necessarily sample at exactly the same places. Their notes indicated that they often seined unusual situations such as deep pools generally found under bridges, whereas we attempted to select areas judged representative of particular parts of streams. Although our procedure possibly omitted some unusual populations, it produced

samples that we believe were more nearly representative of each drainage system.

Sampling Technique.—At each selected site, a stretch of stream approximately 150 feet long was blocked off with one-fourth-inch-mesh minnow seines. A crew of three or four men started at the downstream block with an electric seine and proceeded upstream, collecting all fish that could be seen and captured with dip nets of three-sixteenths-inch mesh. On reaching the upstream block, the crew reversed direction, electrofishing back through the sample area. When the water was exceptionally turbid, a minnow seine was pulled through the enclosed area to recover stunned fish that had been overlooked by crew members using dip nets. Care was exercised to pick up all of the dead and stunned fish that had drifted into the net at the downstream block.

The electric seine used in the small streams was 30 feet long; it had 15-inch drop electrodes spaced at 30-inch intervals. It was powered by a gasoline-driven electric generator having a maximum capacity of 8.7 amperes of 60-cycle alternating current at 115 volts. In wider

streams, a 50-foot electric seine, powered by an 11-ampere, 230-volt alternating current generator, was used. The generator was usually left near the equipment truck, and the electric lead wires were run off a reel having a commutator through which power was supplied as the electrodes were moved up and down the stream.

In the blocked-off areas, we took 77 samples, all within a short period of time (July and August, 1959), thus keeping at a minimum the effects that seasonal changes in fish distribution and abundance might have on our samples. Because for each blocked-off area we made and kept a record of the number of individuals of each species in the sample and their total weight, we refer to a sample from such an area as a quantitative sample.

To supplement the sample taken within each blocked-off area, we seined nearby habitats, figs. 2 and 3. An indefinite number of hauls was made with a 20-foot by 4-foot nylon minnow seine of three-sixteenths-inch mesh. These "cruising" samples usually added several species to the list of fishes taken at each locality. Material obtained outside the blocked-off areas was not included in the quantitative samples. Fish in the "cruising" samples were not measured or weighed.

The reliability of our quantitative samples was not determined. We recognized the selectivity of electrofishing in different habitats and for different species of fishes. For obvious practical reasons, we could not adapt our equipment and procedure to produce the greatest efficiency



Fig. 3.—Seining a shallow pool in the Sangamon River near Mahomet. Habitats of this type contain suckers and minnows. In 1959, collecting with a minnow seine in such habitats usually yielded species not collected with an electric seine in nearby blocked-off areas.

at each station, nor could we determine the efficiency of our electrofishing at each station and still complete the field work in a 2-month period. To keep the number of variable conditions as small as possible and to obtain as nearly comparable samples as was practical, we followed the same procedure at each station. In another study Larimore (1961), using equipment and procedures similar to those used in the 1959 survey, determined electrofishing success in a stream just outside Champaign County. Since the stream was similar to some of the Champaign County streams and since many of the same species were collected, his rate of success is pertinent to evaluating our quantitative samples.

The qualitative completeness of our quantitative samples, that is, the number of species per station in the quantitative samples compared with the number of species per station in the quantitative plus other samples (total collection per station), is shown in tables 13 and 14. Usually about 90 per cent of the species listed at each station were taken in the blocked-off area; the additional 10 per cent were obtained in nearby areas. Our collections averaged 1.4 times as many species per station as did those of Thompson & Hunt. The difference is due probably to our use of two collecting methods and our larger samples. It probably does not reflect a change in the number of species present, nor does it imply inefficiency in the earlier survey, for certainly Thompson & Hunt were remarkably thorough with the method that they employed.

Further evaluations of our collecting efficiency are given in the section General Abundance and Occurrence.

Preservation and Sorting of Collections.—Very large, easily identified fishes were released at the site of capture after their numbers, lengths, and weights had been recorded. All small specimens were immediately put into cans of 15 per cent formalin and taken to the laboratory. Each evening, individuals in the collection were sorted; then, for each species, the numbers, total weights of various size groups, and ranges in lengths were recorded on printed form cards. Only specimens of unusual interest were saved for the permanent collection. Specimens ob-

tained from habitats adjacent to the blocked-off areas were not included in quantitative computations.

Habitat Data Recorded at Site.—A series of standard measurements and an evaluation of certain ecological factors were made at each station. Water level was recorded as high, low, or normal. At each station, depth was measured along transects at the middle and lower part of the study area and in the deepest part of the area. Where great variation in depth occurred, additional measurements were taken halfway between the middle and upper limits and the middle and lower limits of the area. Maximum, minimum, and average widths were recorded on a sketch of the stream section. Current was measured by timing a float as it passed through a 50-foot course judged representative of the water velocity at the station. Turbidity was measured with a U. S. Geological Survey turbidity needle. Types of bottom materials, such as sand, silt, and gravel, were determined, and an estimate was made of the relative abundance of each type. Notes were made of debris and vegetation in the stream, as well as of vegetation on the bank and overhanging the water.

Tabulations.—Quantitative data were recorded on large tabular sheets similar to those used by Thompson & Hunt. Total number and weight for each species in a collecting area were translated into number and weight per 100 square yards of area. This procedure facilitated comparison of our results with those of Thompson & Hunt. The volume of water at each station was calculated and recorded, so that the relations of fish numbers and weights to volume could be ascertained. Also, the measurements and ecological evaluations discussed above were recorded on each sheet. All of this information was transferred to International Business Machine (IBM) punch cards; the results of the classification and analysis of these data were recorded on IBM work sheets, which along with the original tabulations and pertinent notes for both our survey and that of Thompson & Hunt are on file at the Natural History Survey offices.

Supplemental Distribution Records.—In addition to making collections at most of the stations set up by Thompson

& Hunt, we sampled 28 other localities in the county. In sampling these stations, we used either a 20-foot by 4-foot nylon minnow seine of three-sixteenths-inch mesh or a rowboat shocker (Larimore, Durham, & Bennett 1950). The seine sampling, aimed at filling in distributional gaps where blocked-off sampling stations

were widely separated, was of varying intensity and was designed merely to procure a list of species from each locality. Rowboat shocking had the same objective and, with few exceptions, was used only when the stream was too large to permit the effective use of minnow seines. Some sampling by both methods was done on re-

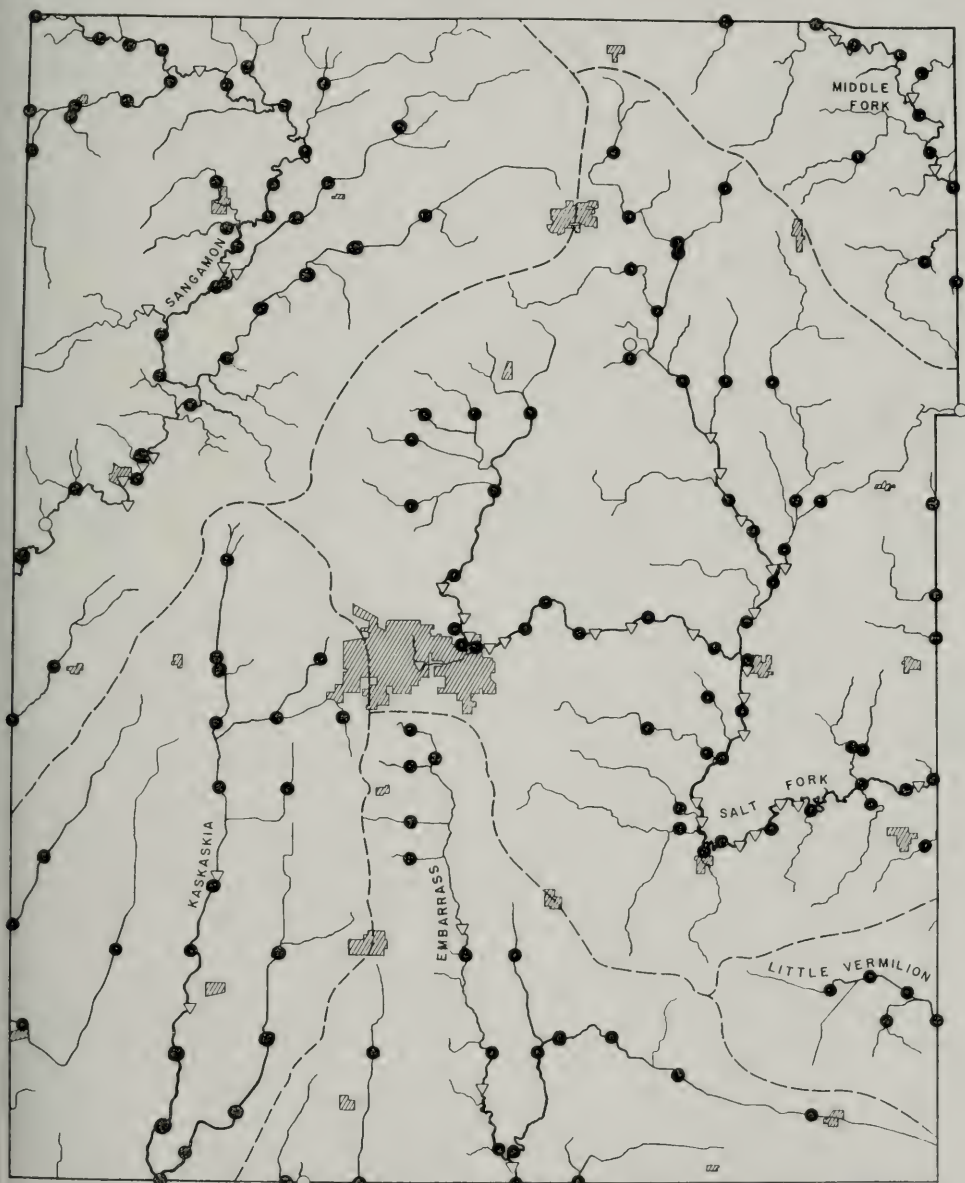


Fig. 4.—Distribution of the 1959 collecting stations (solid circles) in Champaign County. Open symbols represent collecting sites, not revisited in 1959, of the two prior surveys: inverted triangles the Forbes & Richardson survey and circles the Thompson & Hunt survey.

visits to certain stations in an attempt to obtain unusual species that had not been taken on our initial visits, but that had been recorded at the stations by Thompson & Hunt. The streams sampled and the number of collecting stations on each stream, including stations for cruising and supplemental sampling, were as follows: Salt Fork 55, Sangamon 39, Kaskaskia 22, Embarrass 20, Middle Fork 11, and Little Vermilion 5. The distribution of these 152 localities is depicted in fig. 4.

Sources of Additional Information.

—Several Champaign County anglers provided reliable observations. The records they provided were evaluated separately from those of our own collections; their degree of reliability is fully indicated in the Annotated List of Fishes. Two operators of commercial fee-fishing lakes provided information that was used.

DESCRIPTION OF COUNTY

In about a century, much of Champaign County has been converted from marshland infested with deer flies to well-drained, fertile farmland. It has been intensively cultivated for several decades, and its streams have been modified by dredging, tiling, silting, and other influences that accompany agricultural practices. The human population has mushroomed in recent years, and some areas have become industrialized, providing an opportunity to observe the effects of sewage and industrial wastes on streams and stream life.

Located in east-central Illinois, Champaign County, fig. 5, is 36 miles from north to south and 27 miles from east to west. It occupies 988 square miles (632,415 acres) of flat to slightly rolling land; the present relief resulted from relatively recent glaciation and from postglacial stream erosion. The altitude ranges from 630 to 860 feet above sea level and averages about 710 feet. Although essentially a flat plain, it is somewhat higher than surrounding counties, and four major stream systems arise within the county. Two other stream systems originate a short distance north of the county limits.

The county has been glaciated twice, but the effects of the more recent Wisconsin stage (about 18,000 years ago) obscure those of the much older Illinoian

stage. The series of end moraines, which rise from 50 to 100 feet above the inter-morainal basins, usually form boundaries between drainage systems. The entire



Fig. 5.—Location of Champaign County and its streams in relation to the state and major drainage systems. The dotted line indicates the boundary of a particularly fertile area, at one time mostly prairie marsh.

county is overlaid with a mantle of Wisconsin glacial till, which is covered with a layer of loess of varying thicknesses up to 8 feet, except where the loess has been eroded away. The county contains no rock outcrops.

Soils

The soils reflect the soil parent material, the drainage, and the vegetational history of the area. Dark upland prairie soils make up about 92 per cent of the area; yellow-gray silt loams, the upland timber soils, make up about 5 per cent; bottom-land or terrace soils constitute the small remainder (Hopkins *et al.* 1918:6).

A recent arrangement of the soil types of Champaign County is presented in the

following paragraph (Fehrenbacher 1963 and personal communication from Dr. Russell T. Odell, Professor of Soil Pedology, University of Illinois).

The dark upland prairie soils can be placed in four general groups. A group of silty loess prairie soils (mainly Drummer, Flanagan, and Catlin soil types) covers about 40 per cent of Champaign County. These soils are loam till covered with 3 to 5 feet of loess. Properly managed, they are the most productive in the county, averaging about 95 bushels of corn per acre per year. A second group of prairie soils, mainly Drummer, Brenton, and Proctor soil types, consists of silty outwash soils with greater subsurface flow and higher permeability than the first group mentioned. They cover about 26 per cent of the county and also are very productive. This group of soils is associated with the former marshes. A third group, made up of medium-textured prairie soils, occurs in rolling areas mostly along the Champaign Moraine and covers about 10 per cent of the county. A fourth group, composed of fine-textured prairie soils of silty clay loam and silty till, covers a large area in the northeastern part of the county and scattered areas in the northwestern part, a total of 16 per cent of the county. This group is somewhat less productive than the other prairie soils. The small remaining group, consisting of nonprairie soils, is generally associated with the river valleys and constitutes the least productive soils in the county.

Weather

Champaign County has a temperate continental-type climate without the modifying influences of a large body of water. In most years, temperature extremes range from well below 0 degrees to slightly over 100 degrees F. The annual mean temperature is 52 degrees F. (Changnon 1959:46). Comparison of monthly average temperatures over a 57-year period during which weather records have been kept at Urbana reveals great fluctuation but no significant trend. August, the month of our most intensive collecting in 1959, was considerably warmer than the August average.

The county receives an average of about 36 inches of precipitation per year.

Although the annual averages for 1929–1958 were similar to those for the preceding 1903–1928 period, judged by data graphically presented by Changnon (1959:11), the 5-year period immediately preceding Thompson & Hunt's study was exceptionally wet, and the years 1930, 1953, 1954, and 1956 were exceptionally dry, the annual rainfall being less than 30 inches. The years 1940 and 1959 received subnormal amounts of precipitation and were marked by unusually dry summers. The summer months of 1959 were extremely dry and resulted in low water levels during the time of our intensive field work.

Agricultural Practices

Champaign County is one of the most productive grain areas in the world. During more than a century of farming, this county has undergone great changes in landscape, in farming methods, and in crops. These changes include the draining of the wet prairies and marshes to convert them to productive farmland, the use of large machinery, and the widespread use of commercial fertilizers and new and improved plant varieties.

The farming of the first settlers in this county was largely restricted to raising cattle and small crops on the high areas and along the stream courses where drainage was naturally good. Lands that were dry enough for cultivation were turned by oxen. During the last quarter of the nineteenth century, ditches were dug and tiles laid to drain the wet prairie fields. By 1900, the farms averaged between 80 and 100 acres in size.

With the development of large farm machinery—heavy tractors, combines, seeders, and corn pickers—many farms were merged to form larger ones. Currently, the average Champaign County farm is about 200 acres. Within the past 30 years a trend toward less diversification among farm crops has appeared; corn and soybeans have become the two leading crops.

During the 1940's, the widespread use of commercial fertilizers brought about a general increase in average yield. Hybrid plants and improved varieties added to yields. Recently, liquid nitrogen as a fertilizer has further increased production.

At the time of settlement of Champaign County, very little soil eroded from the prairie and timber areas, but intensive farming made erosion a serious, constant threat even in the nearly flat or gently sloping lands of Champaign County. As the native vegetation was removed and the soil directly exposed to rain and wind, the soil became compact and less absorbent, causing more rapid runoff, accompanied by the loss of rich topsoil. The inadequacy of soil conservation practices had adverse effects upon the streams and contributed to more frequent floods followed by seriously low water levels. The effects of soil erosion and the need for intensive conservation methods are not fully appreciated by many Champaign County farmers. Few grainfields are farmed on the contour, strip cropping is rare, and grass waterways are maintained in relatively few of the cultivated fields. Farm animals are permitted to graze the stream banks and thereby contribute to serious erosion and siltation.

Population, Urban, and Industrial Developments

During the first half of the twentieth century, striking changes in land use in Champaign County were brought on by the increasing human population. In 1900, the census reported 47,622 people residing in the county; in 1930, 64,273; in 1960, 132,436. The trend has been toward urbanization; in 1900, 31.1 per cent of the population lived in urban areas and, in 1960, 75.6 per cent. Although there are about 26 cities and villages in the county, only Champaign-Urbana, Rantoul, and a few others have increased in population. Some of the small villages in the county have remained static in population or have even declined. The changes in size of urban areas is illustrated by fig. 6, which shows the village limits of the 1870's in red and the recent limits in black.

A considerable acreage of farmland has been usurped by urban and suburban development. The total number of acres in cultivation was roughly the same between 1900 and 1928 and was considerably greater than it is today. Since 1928, cleared land, particularly that marginal to cities and villages, has been pressed into nonagricultural uses. Many areas

that were once farmed now are covered by modern schools, grain storage units, and industrial developments; other large land areas now are occupied by Chanute Air Force Base and the campus of the University of Illinois. These lands are permanently out of production of farm crops. The vast network of roads, including several major highways that transect the county, occupies a large and ever-increasing area.

A highly developed road system has made Champaign County ideally suited for the study reported here because roads are laid out, orderly and regularly, parallel to each other at mile or half-mile intervals throughout the county. All streams could be sampled conveniently at almost any point, and electrofishing and other heavy collecting gear could be transported by automobile almost to the water's edge.

Stream Drainages and Courses

The stream drainages of Champaign County can be summarized as follows. Six rivers have headwater channels in the county, four of which (Salt Fork, Embarrass, Kaskaskia, and Little Vermilion) actually originate within the county. All of the drainages are separated by moraines, except the Sangamon and Salt Fork; during times of flood, headwaters of the Sangamon and Salt Fork may connect, although connection occurs much less frequently now than formerly. The total drainage area (in square miles) of each of these rivers within the county is as follows: Sangamon 277, Salt Fork 346, Middle Fork 69, Embarrass 138, Kaskaskia 168, and Little Vermilion 40. A few smaller streams flow out of the county, but each joins one of the six larger rivers a short distance beyond the county border. The relationships of the streams to the larger rivers are shown in fig. 5.

The total drainage area (in square miles) of the main course of each of these rivers at the point the river leaves Champaign County is as follows: Sangamon 388, Salt Fork 307, Middle Fork 241, Embarrass 106, Kaskaskia 98, and Little Vermilion 28. These figures include upper reaches of those rivers that rise outside the county.

Water Discharge.—Annual average discharge records for two gaging sta-

tions near the periphery and for three stations well within the county are available, table 1. The records show the size of the streams at these stations and indicate the amount of water drained from the different watersheds. Calculated from fig-

ures in table 1, the annual average discharge of water per acre in the period ending in 1957 was 0.7 cubic feet per second (c.f.s.) for the Sangamon, Salt Fork, and West Branch; 0.6 c.f.s. for the Kaskaskia; and 1.0 c.f.s. for the Bone-

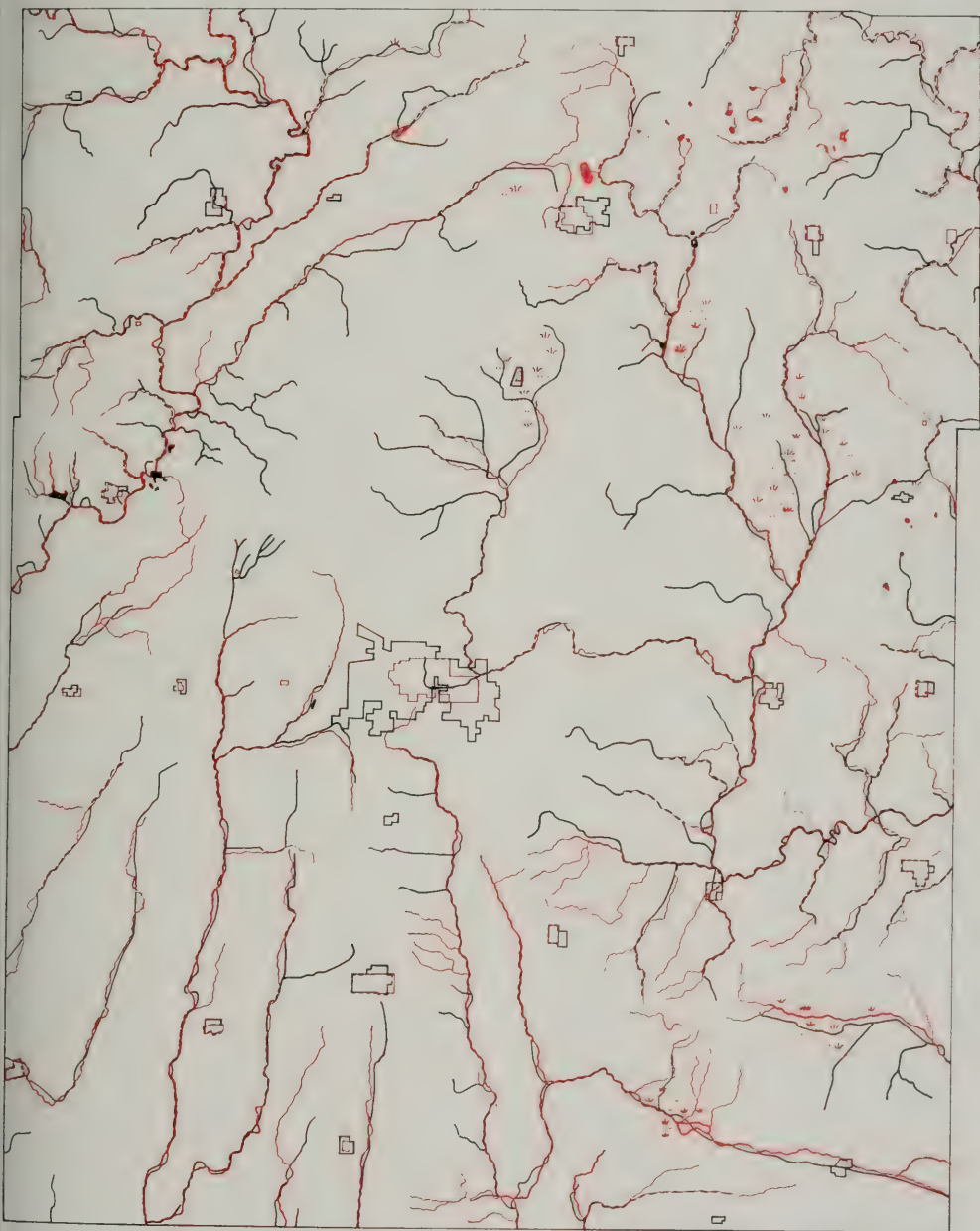


Fig. 6.—Distribution of towns and water areas in Champaign County in the 1870's (in red) and 1950's (in black). Drawn from map in *Atlas of the State of Illinois* (Anon. 1876) and U. S. Geological Survey Quadrangles (editions 1950-1957).

Table 1.—Water discharge records taken at five gaging stations in Champaign County (U. S. Geological Survey, 1953–1960).

STREAM	LOCATION OF STATION	WATERSHED, SQUARE MILES	ANNUAL AVERAGE DISCHARGE (C.F.S.)	YEARS OF RECORDS
Sangamon.....	Near Mahomet	356.0	249.00	1948–1957
Salt Fork.....	Near Homer	344.0	243.00	1944–1957
Kaskaskia.....	Near Bondville	12.3	8.05	1949–1957
Boneyard.....	Near Urbana	4.6	4.62	1948–1957
West Branch.....	Near Urbana	71.4	50.40	1936–1957

yard. The lowest discharge per acre was for the Kaskaskia drainage, which is entirely farmland, and the highest discharge was for the Boneyard drainage, which is almost entirely urban, lying within Champaign-Urbana.

The records on the Sangamon River taken near Monticello are of special value in that they show changes in stream discharge over a long period. Although the gaging station is about 10 miles outside Champaign County, it records the runoff from one-quarter of the county. Records are nearly complete back to 1908. They show that annual average discharge fell below 200 c.f.s. only once during the two decades before the Thompson & Hunt study of 1928, but fell below this level eight times in the three decades since. The low discharges in recent years indicate the reduced water-holding capacity of soils of the watershed. The river now responds quickly to precipitation or drought, whereas it had a more nearly constant flow before 1928.

The minimum discharge of a stream has great significance to fish distribution. Before the Thompson & Hunt study, there was no record of the Sangamon River discharge dropping as low as 1.0 c.f.s. but it reached 1.0 c.f.s. or lower five times in the three following decades. As might be expected, there is a high correlation between precipitation and water discharge of streams in an area. There is, of course, a variable time lag between precipitation and discharge.

Draining and Dredging.—Because of the original marshy character of Champaign County, much draining, dredging, and straightening of waterways has been necessary to prepare the land for agriculture.

The Illinois Farm Drainage Act of 1879 encouraged the formation of drainage districts and enabled farmers to participate in the installation of drainage systems to serve large areas. Drainage proceeded rapidly during the following two decades, and, by the turn of the century, when Forbes & Richardson made the first extensive fish collections in the area, 36 per cent of the county's 632,415 acres had drainage improvements, table 2.

The number of acres in drainage districts almost doubled between 1900 and 1910, with 190,205 additional acres (30 per cent of the county) receiving drainage improvements. In the decades since 1910, the amount of new land drained has declined, table 2. The acreage of land placed in drainage districts in the three decades between 1930 and 1960 amounted

Table 2.—Acres of land in Champaign County placed in drainage districts during each period since about 1880 and the per cent of the county (632,415 total acres) with drainage improvements by the end of each decade. Information from the Federal Land Bank of St. Louis and Champaign County records.

PERIOD	ACRES PLACED IN DRAINAGE DISTRICTS	PER CENT OF COUNTY WITH DRAINAGE IMPROVEMENTS
Pre-1891	162,298	26
1891–1900	66,951	36
1901–1910	190,205	66
1911–1920	23,524	70
1921–1930*	24,174*	74*
1931–1940	22,838	77
1941–1950	16,064	80
1951–1960	14,046	82

*In 1921–1930, 3,060 previously unrecorded acres that had received drainage improvements prior to 1927 (dates unknown) were included in the acreage total for this period, column two, and taken into account in the percentage figures for this and later periods, column three.

to only 8 per cent of the area of the county.

When Thompson & Hunt made their collections in 1928, 74 per cent of the county was in drainage districts. By 1959, 82 per cent of the county (520,100 acres) had received drainage improvements. Of the 18 per cent of the county remaining, probably a considerable proportion has adequate natural drainage or is in non-agricultural use. Future drainage probably will consist mostly of maintenance and improvement of existing systems.

Dredging to increase the water-carrying capacity of existing streams, or to create ditches in the undrained marshy areas where none existed, eliminated areas of standing water and created new channels. Recanalization of natural streams resulted in much straightening, in the erection of high earthen banks along the sides, in producing greater uniformity of the stream environments, and in drastically altering local habitats, fig. 11.

Subsurface drain tiles reduced areas of standing water and in some places resulted in burying what had been surface drainage courses. As a result, many small, intermittent streams have been replaced by field tiles or by wide, carefully graded grass waterways.

Draining and dredging, which have reduced the water storage capacity of the watershed, have contributed to higher flood levels and lower drought levels in the streams. These practices have lowered the water table and affected the permanency of many small streams. Since the early 1870's, work has been directed toward improving the drainage in Champaign County; in the future this objective may need considerable modification as demands for water supplies increase and efforts are made to hold water to meet these demands.

Some stream courses have been altered. Slight changes in drainage boundaries can be seen on the upper reaches of Hayes Creek, Copper Slough, Camp Creek, the Salt Fork above Rantoul, and the headwaters of the Little Vermilion stream.

Two stations where Thompson & Hunt seined, one in a small tributary of the East Branch of the Salt Fork about 3 miles southeast of Rantoul, and one in a tributary of Hayes Creek on the Cham-

paign-Douglas county line, were no longer extant in 1959. They had been replaced by grass waterways. Near St. Joseph, the Salt Fork had been straightened, leaving a large oxbow at the west edge of town. Numerous small streams visited in 1928 by Thompson & Hunt were completely dry in the summer of 1959, due probably to the dry summer rather than to modifications by man or to long-term natural changes.

Some stream changes, including new channels and new meanders, were natural. Such changes as occurred in the county between the mid-1870's (shown in red) and the mid-1950's (shown in black) can be detected in fig 6.

STREAM HABITATS

Most Champaign County streams originate at drain tiles, fig. 7, on the slopes of moraines, or in flat, marshy areas. They flow through straight, usually man-made ditches in rich farmland and move on into less disturbed channels as they become larger and their valleys widen. Certain general ecological characteristics are common to these streams and can be used to distinguish and describe several stream habitats.

General Ecological Characteristics

In Champaign County, the relatively flat topography, the lack of rock outcrops, the similarity of soil materials, and the intensive land-use practices produce an unusual amount of uniformity in the stream environment.

The stream gradient is generally low, usually between 3 and 4 feet of fall per mile. Only on the slopes of moraines and in a few short stretches does it exceed 6 feet per mile. The flow is generally moderate to sluggish during normal water stages. Riffles are gentle and pools are rather shallow. There are long stretches of very uniform depth and flow.

Water levels fluctuate rapidly and drastically. Flooding occurs with some regularity, particularly during the spring and early summer. At normal water stages, streams have levels well within their steep-sided banks. During flood stages, the water levels may rise 10 to 15 feet and temporarily become torrents that erode away stream banks. Within the county,

the Sangamon, Salt Fork, Middle Fork, and to a lesser degree the Embarrass rivers have narrow floodplains, which may be completely inundated during floods. Severe dry periods occur nearly every year, usually during August and September. The flow may decrease drastically or even cease. The small headwater tributaries suffer most regularly and severely from dry weather conditions.

Water temperatures in small, shallow, stagnant pools may approach 100 degrees F. during the summer and 32 degrees in the winter. There are no large springs to moderate water temperatures. The lack of shading bank vegetation along shallow areas allows extreme daily fluctuations of temperature, which, in summer, may change as much as 20 degrees F. between the cool morning hours and the hot mid-afternoon. In winter, temperatures may drop sufficiently to freeze the water to the stream bottom in shallow areas. Because fish generally concentrate in deep pools, they are seldom caught in the ice.

The distribution of bottom materials, formed from the basic glacial till, is di-

rectly related to the velocity of the water. Through selective sorting of the basic materials, rubble and gravel (the heaviest materials) pile up in riffle areas, sand in areas of moderate current, and the finer particles of silt and clay drop out only in the quiet waters of the deep pools.

Turbidity is generally high, becoming low only during the cold months, when the activity of fish is reduced so much that it does not roil silt on the bottom and when streams are said to be "winter clear." During the field work for the present study, turbidity ranged between 15 and 150 parts per million (p.p.m.).

The chemistry of stream water, basically related to the mineral composition of the watershed, may be strongly influenced by domestic and industrial pollution, table 3. Water in the lower Embarrass, Kaskaskia, Spoon, and Sangamon rivers, which are relatively unpolluted, is low in ammonium, phosphate, and nitrate, in comparison with water from the polluted areas in the Salt Fork River. Hardness (as calcium carbonate content) ranges from 264 to 436 p.p.m. The pH is slightly

Table 3.—Partial chemical analysis of water collected from seven stream locations in Champaign County on December 29, 1960. The streams were mostly ice covered and at normal water level. Temperatures of samples ranged from 32 to 34 degrees F. The water had no measurable color or odor. Turbidity was less than 24 p.p.m. Analysis was made by the Illinois Water Survey. All figures are for p.p.m.

STATION	AMMONIUM	NITRATE	PHOSPHATE	CHLORIDE	SULFATE	SILICA	ALKALINITY (as CaCO ₃)	HARDNESS (as CaCO ₃)	TOTAL DISSOLVED MINERALS	ALKYL BENZENE SULFONATE
Embarrass North of Villa Grove.....	0.2	2.8	0.1	13	111.7	8.7	284	392	477	0.0
Sangamon Northeast of Mahomet.....	0.3	5.8	0.0	32	115.0	4.5	304	428	555	0.1
Kaskaskia West of Parkville.....	tr.	6.5	0.5	7	19.1	11.4	303	264	370	0.1
Spoon River North of St. Joseph.....	0.5	2.4	0.1	13	152.6	10.4	320	436	555	0.0
East Branch North of St. Joseph.....	7.4	18.2	13.1	255	85.6	14.0	292	372	850	0.7
West Branch East of Urbana.....	7.5	14.9	47.4	100	193.2	14.4	360	376	842	1.2
Salt Fork Northwest of Homer.....	4.8	15.9	22.2	116	107.2	15.0	312	336	705	0.9

above neutral, most of the readings ranging from 7.2 to 7.8. The amount of dissolved oxygen varies from supersaturation in well-aerated riffle areas to less than 1 p.p.m. in highly polluted waters and in stagnant pools when the stream flow is discontinuous.

Much of the natural aquatic vegetation in Champaign County streams may have been eliminated early in this century through dredging, pollution, and other man-induced alterations. The remaining vegetation is limited in distribution by the generally high turbidity of the streams.

Baker (1922) illustrated many of the stream habitats along the Salt Fork as they appeared in 1919 and 1920. Except for a large patch (which no longer exists) of yellow water lilies, *Nuphar advena*, northeast of Sidney, the vegetation seen in his photographs is similar to that found at present. Moreover, his description of the aquatic vegetation includes essentially the same species that now occur in the area.

Thompson & Hunt listed the common coarse aquatic plants that they observed. Their list includes most of the present vegetation. They listed four species of *Potamogeton* that we did not find associated with the flowing waters of the county; however, we observed another species of *Potamogeton*, believed to be *P. foliosus* Rafinesque, in a number of streams and found it to be quite common in the upper reaches of Lone Tree Creek near Foosland. The field notes of Thompson & Hunt and our observations indicate that aquatic vegetation was more extensive in 1928 than it is today.

Dr. Robert A. Evers, of the Section of Applied Botany and Plant Pathology of the Natural History Survey, examined plants in several collections we made during the present study. His identifications add the following species to the list presented by Thompson & Hunt:

Equisetum arvense Linnaeus
Spartina pectinata Link
Carex cristatella Britton
Salix interior Rowlee
Rumex altissimus Wood
Rorippa islandica (Oeder) Borbas
Lysimachia nummularia Linnaeus
Asclepias incarnata Linnaeus
Phyla lanceolata (Michaux) Greene

Lycopus americanus Muhlenberg
Eupatorium perfoliatum Linnaeus
Hibiscus militaris Cavanilles

These plants are not true aquatics but are characteristically associated with the banks and mud flats along most of the streams. A few true aquatics deserve special comment. *Potamogeton foliosus* has already been mentioned as quite common in part of Lone Tree Creek. *Elodea canadensis* Michaux occurs in large patches in the polluted West Branch between Urbana and St. Joseph. *Dianthera americana* Linnaeus is abundant on the riffles and along the shores of many streams, especially in the Middle Fork. *Chara* sp. was taken near a seepage spot on a tributary of the Spoon River near Flatville.

The vegetation we observed in our study included grasses, sedges, ragweeds, milkweeds, docks, and several composites along the small streams as they passed through flat and open farmlands. In some of the reaches of these streams, willows and scrubby growths of a few other deciduous trees overhung the water. Tall deciduous trees lined the banks of most of the large streams. Especially common were silver maple, American elm, cottonwood, sycamore, and willows. In open areas, where the sunshine reached the water, grew buttonbush, rose mallow, water willow, and a few other plants.

Habitat Types

Although the general ecological characteristics of the streams of Champaign County are rather uniform, each stream contains several distinct habitats. The habitats are determined largely by stream size, stream topography and gradient, soil materials comprising the bottom, and human modification of the stream and its drainage basin.

Thompson & Hunt (1930:34-9) classified stream habitats according to size of area drained, permanency, depth, width, current, type of substrate, amount of vegetation and debris, turbidity, and faunal composition. They recognized vernal rivulets; kettle holes at mouths of tile drains; oxbow ponds along small streams; permanent headwater streams; stretches of shallow, sluggish water; gravelly and sandy riffles and stretches; rocky rapids

Table 4.—Champaign County stream habitats, the extent of their occurrence, and their physical characteristics.

HABITAT	MILES IN COUNTY	DRAINAGE AREA (SQUARE MILES)	AVERAGE GRADIENT (FEET PER MILE)	MAXIMUM DEPTH (RANGE IN INCHES)	CURRENT
Rivulet and small creek	189	10	7	1-10	Variable
Large creek	176	10-200	3	-----	-----
Riffle	-----	-----	-----	-----	-----
Sand and fine gravel	-----	-----	-----	1-12	Swift
Gravel and boulder	-----	-----	-----	1-12	Swift
Pool	-----	-----	-----	-----	-----
Shallow	-----	-----	-----	4-24	Moderate
Deep	-----	-----	-----	24-48	Sluggish
Small river	58	200-400	2	-----	-----
Riffle	-----	-----	-----	-----	-----
Sand and gravel	-----	-----	-----	3-18	Swift
Boulder and rubble	-----	-----	-----	3-18	Swift
Pool	-----	-----	-----	-----	-----
Shallow	-----	-----	-----	18-36	Moderate
Deep	-----	-----	-----	36-96	Sluggish

and riffles; moderately deep, smoothly flowing stretches; and long, deep pools. They described each habitat and listed characteristic species of fishes.

We prefer a classification based on the same ecological characteristics but having divisions with more easily definable limits, table 4.

Rivulets and Small Creeks.—Our rivulets and small creeks include the vernal rivulets of Thompson & Hunt and also intermittent streams of slightly greater size. They arise as small open

gullies coming off the face of moraine slopes, as seeps in grass waterways, or as discharges at field tiles, fig. 7, draining flat marshy areas. The type that originates at a field tile may have an unusual beginning because of the large, and sometimes surprisingly deep, hole that is scoured out at the base of the tile. In many cases, the pool contains a large concentration of fish.

Most rivulets and small creeks in Champaign County have been modified by dredging and straightening of the chan-



Fig. 7.—Drain tile mouth and pool on the East Branch of the Salt Fork of the Vermillion River. A tile mouth is Champaign County's analogue of a spring.

nel. They consist of a long open ditch, flowing smoothly over a substrate of clay, silt, or loam. They lack aquatic vegetation but are bordered by grasses, herbs, and shrubs. Although they include occasional water pockets that could be termed pools, and occasional shallow areas where there is an accumulation of sand and gravel suggesting riffles, their distribution of fishes is relatively uniform throughout. These long open ditches may partially dry up if water flow ceases during the summer months. Their small size, instability of flow, and lack of shade produce a highly unstable aquatic environment.

Large Creeks.—The streams we classify as large creeks are formed by the confluence of the rivulets and small creeks. The water contributed by the network of tributaries is of such volume that flow is continuous throughout most years, although the actual volume may fluctuate drastically from wet to dry seasons. Typically, the large creeks consist of alternating pools, shallow stretches, and riffles (frontispiece). They contain a greater

variety of habitats than do rivulets and small creeks. The frequency of occurrence of riffles depends upon the distribution of glacial drift materials, the extent of dredging, and the stream gradient. Some of the large creeks in Champaign County have been dredged; they now have straight rather than meandering courses, a monotonous sameness of environment, and nearly uniform depth, fig. 8.

In the large creeks, riffles over sand and fine gravel are usually without aquatic vegetation; those over gravel and small boulders have some attached algae. Some pools are shallow and have a moderate flow over clay, sand, and silt; they have a variety of aquatic vegetation. Other pools are quiet and deep, having been formed by obstructions or unusual erosion of the bottom materials; they have accumulations of silt and only marginal vegetation. Long, shallow pools make up large proportions of most of the Champaign County streams we have classified as large creeks, fig. 11.

Small Rivers.—The largest streams in the county, hardly larger than creeks



Fig. 8.—The Kaskaskia River southwest of Parkville. This stream, dredged from time to time, illustrates one of the large creek habitats found in Champaign County. Modification of this creek resulted in an unusual amount of sand in the stream bed.



Fig. 9.—Upper picture: a shallow pool in the Sangamon River near Fisher. Habitats such as this contain several species of suckers, basses, and sunfishes, and many species of small fishes. Lower picture: a deep pool in the Salt Fork near Homer. Habitats such as this contain carp, catfish, shad, and relatively few species of small fishes.

by some standards, we have classed as small rivers, figs. 2 and 3. They include the lower Sangamon, the lower Salt Fork, and the Middle Fork. They are permanent streams that have less extreme and less sudden fluctuations in water level and temperature than creeks. Their floodplains and banks are generally shaded by large trees, fig. 9. Like large creeks, the small rivers contain both riffle and pool habitats, table 4.

Riffles of small rivers differ from those of creeks in their greater volume of flow and their greater proportion of large-sized bottom materials. Because of the low gradient of the small rivers, the riffles in these streams are relatively fewer in number and occupy a smaller proportion of the total water area than do those in creeks. Sand and fine gravel riffles with little aquatic vegetation occur in small rivers as well as creeks; because sand and fine gravel occur also in many boulder and rubble riffles that have some aquatic vegetation, the two types of riffles are less clearly defined in rivers than in creeks.

Pools in small rivers are either shallow and have moderate water flow, or deep and have sluggish current, fig. 9. Their characteristics are similar to those of large creeks, but the pools are deeper and have more overhanging vegetation and greater silt deposits. In certain parts of the lower Salt Fork and lower Sangamon, occasional pools are quite deep and have very sluggish water movements.

Other Aquatic Habitats.—Other Champaign County aquatic habitats that do not fit into the above classification are nonstream habitats, such as farm ponds, artificial lakes, and oxbows. No natural lakes and no permanent swamps and marshes remain in the county. Ponds and artificial lakes are of little interest in the present study inasmuch as they have been stocked, and they are of concern only if the fishes they contain spill over into the streams. Oxbows have characteristic lacustrine populations. The component species obviously were derived from the streams with which the oxbows were once associated.

Changes in Stream Habitats

The environment of a stream is sensitive to almost any activity within the

watershed. It is influenced by the human population, agriculture, and industry as outlined previously in this paper.

For the 30-year period between the studies of Forbes & Richardson and those of Thompson & Hunt, specific measurements or observations of the stream environment were limited to some studies of stream-flow measurements and draining activities. From these studies and the information on the general development of the county, we know that many water habitats were actually eliminated and that draining and dredging resulted in increased fluctuation of water levels, increased turbidity, and a reduction in aquatic vegetation. We know that channel straightening, with the elimination of meanders, actually shortened stream courses in many areas and consequently increased the stream gradient. The replacement of stagnant-water marshes by underground drains that discharge waters that are relatively cool in summer and warm in winter may have reduced seasonal fluctuations of stream temperatures.

Between the investigations of Thompson & Hunt in 1928 and the present time, we have specific information on certain changes that have occurred. Thompson & Hunt's original field notes provide an unusual opportunity for evaluating various changes in habitats at identical, or nearly identical, collecting sites, figs. 10 and 11. Habitat differences can be seen at specific sites described by Thompson & Hunt and then examined 30 years later during the 1959 investigation. These differences have been evaluated and summarized in table 5.

The principal changes noted have to do with dimensions, particularly in average depth and average width of the pools where collections were made. The field work of the 1928 survey was carried on "from early spring to late autumn" (Thompson & Hunt 1930:14); most of our collections were concentrated in the dry months of late summer. The entire summer of 1959 was considerably drier than that of 1928. Despite differences in the time of field work and in the amount of precipitation in 1928 and 1959, the two censuses disclosed that measurable changes had taken place in the Champaign County drainage systems in the years between the censuses, table 5.



Fig. 10.—The Sangamon River near Mahomet in the autumn of 1928 (above) and the autumn of 1962 (below). The habitats at this site have remained relatively unchanged.



Fig. 11.—The Kaskaskia River near Bondville in the autumn of 1928 (above), some years after it had been dredged, and in the autumn of 1962 (below), after another dredging. Here the Kaskaskia is classed as a large creek.

Table 5.—Changes in stream habitat characteristics of various Champaign County drainages as indicated by the percentage of stations that showed a decrease (—), the percentage that remained the same (0), and the percentage that showed an increase (+) in each of these characteristics between the Thompson & Hunt study in 1928 and the 1959 study. Only those stations are included for which most of the habitat data are available.

DRAINAGE	NUMBER OF STATIONS	DEPTH	WIDTH	GRAVEL	SAND	SILT	AQUATIC VEGETATION	OVER-HANGING VEGETATION	VELOCITY
		— 0 +	— 0 +	— 0 +	— 0 +	— 0 +	— 0 +	— 0 +	— 0 +
Sangamon	25	52 40 8	16 48 36	52 48 0	0 48 52	0 48 52	4 96 0	20 76 4	20 76 4
Kaskaskia	11	73 27 0	0 36 64	64 36 0	0 36 74	74 36 0	9 82 9	36 55 9	0 0 100
Embarrass	10	30 70 0	10 60 30	10 90 0	0 90 10	0 90 10	30 60 10	0 90 10	0 100 0
Salt Fork	20	35 55 10	15 40 45	25 75 0	0 75 25	0 75 25	30 55 15	15 65 20	0 95 5
Middle Fork	5	40 60 0	20 20 60	80 20 0	0 20 80	0 20 80	20 30 0	0 60 40	0 100 0

All of the Champaign County drainage systems showed a decided trend toward a decrease in depth and an increase in width, table 5. All of them showed a decrease in gravel and an increase in sand. All but the Kaskaskia River showed an increase in silt, which had covered the gravel or sand present in 1928. In the Kaskaskia, however, sand deposits had covered over both the gravel and silt formerly recorded, fig. 8. A general decrease was evident in the occurrence of aquatic vegetation; an increase had occurred, except along the Sangamon and Kaskaskia rivers, in the amount of overhanging vegetation. Only in the Kaskaskia was there a striking change in water velocity, an increase caused by recent dredging and straightening of the river and perhaps by the introduction of large volumes of well water in its upper reaches. Except for the general increase in width and the unusual conditions cited for the Kaskaskia River, the changes noted were precisely those which could be expected in view of the changes in land use and landscape appearance outlined earlier. Study of the values in table 5 for decrease, unchanged status, and increase for each characteristic in each drainage system reveals the degree of these changes.

ANNOTATED LIST OF FISHES

Ninety species are included in our annotated list of the fishes of Champaign County. One of these, *Hybopsis aestivalis*, is questionable for reasons given subsequently. A few other species, not in the annotated list, are known from streams in adjacent counties and may eventually be found in this county. These species of hypothetical occurrence are *Carpionodes carpio carpio* (Rafinesque), *Moxostoma carinatum* (Cope), *Stizostedion canadense* (Smith), all of which have been taken a short distance downstream in the Salt Fork of the Vermilion in adjacent Vermilion County, and *Etheostoma camurum* (Cope), taken in the Middle Fork of the Vermilion in Vermilion County. A few other species, reported by Champaign County fishermen but not examined by us or documented by specimens, have not been included in our list. Of the 90 species in the annotated list, 74 were taken during 1959 or have been taken since.

The fishes have an unusually complex synonymy. Accordingly, in the following list, the name applied to a Champaign County species by earlier authors is given in every case where the current name differs from that in the literature. In several cases, the "species" of earlier investigators were composites of two or more species as now recognized. Because of these composite species, most of the existing specimens in the Thompson & Hunt collections and a few in the Forbes & Richardson collections have been re-examined and reidentified.

A summary of collections for all three surveys is given. FR refers to Forbes & Richardson, TH to Thompson & Hunt, and LS to Larimore & Smith. The number following the initials designates the number of localities represented; the term "all drainages" following a number indicates that all drainage systems of Champaign County were represented. A "?" following FR or TH indicates some doubt as to whether the species involved was included in the nominal species of Forbes & Richardson (1908) or Thompson & Hunt (1930). Names of drainages from which species were collected are given in parentheses.

Amiidae

Amia calva Linnaeus. Bowfin.—Several large adults taken by rowboat shocker from Kaufman's Clear Lake, where they had been introduced for sport fishing. LS 1 (Kaskaskia).

Lepisosteidae

Lepisosteus osseus (Linnaeus). Long-nose gar.—A large adult taken by rowboat shocker in the Middle Fork where it leaves the county. The species was probably missed by earlier investigators because of its rarity in the county. LS 1 (Middle Fork).

Hiodontidae

Hiodon alosoides (Rafinesque). Gold-eye.—One specimen known from Champaign County. This specimen, taken on the Kaskaskia River at the lowermost station in the county and reported as *Hiodon tergisus* by Thompson & Hunt, is still extant and is reidentified as *H. alosoides*. TH 1 (Kaskaskia).

Clupeidae

Dorosoma cepedianum (Le Sueur). Gizzard shad.—FR 3 (Kaskaskia), TH 2 (Sangamon), LS 12 (Embarrass, Salt Fork, Sangamon).

Esocidae

Esox americanus vermiculatus Le Sueur. Grass pickerel.—Reported as *Esox vermiculatus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 10 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 26 (Kaskaskia, Embarrass, Little Vermilion, Salt Fork, Sangamon), LS 17 (all drainages).

Catostomidae

Carpionodes cyprinus hinei Trautman. Central quillback carpsucker.—Reported as *Carpionodes velifer* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 10 (Salt Fork, Middle Fork, Sangamon), TH 9 (Middle Fork, Sangamon), LS 27 (Salt Fork, Middle Fork, Sangamon).

Carpionodes velifer (Rafinesque). High-fin carpsucker.—Reported as *Carpionodes difformis* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 8 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 4 (Middle Fork, Sangamon), LS 9 (Salt Fork, Middle Fork, Sangamon).

Catostomus commersoni commersoni (Lacépède). White sucker.—FR 14 (Salt Fork, Middle Fork, Sangamon), TH 63 (not 65 as stated: all drainages), LS 76 (all drainages except Little Vermilion).

Erimyzon oblongus claviformis (Girard). Western creek chubsucker.—Reported as *Erimyzon sucetta oblongus*, a composite of *E. sucetta* and *E. oblongus*, by Forbes & Richardson, Thompson & Hunt, and other early authors. There is no evidence that *E. sucetta* ever occurred within the county, although it is known from deep quarries in adjacent Vermilion County. FR 22 (all drainages except Little Vermilion), TH 43 (all drainages), LS 79 (all drainages).

Hypentelium nigricans (Le Sueur). Northern hog sucker.—Reported as *Catostomus nigricans* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 7 (Salt Fork, Middle Fork, Sangamon), TH 27 (all drainages ex-

cept Little Vermilion), LS 42 (all drainages except Little Vermilion).

Ictiobus bubalus (Rafinesque). Smallmouth buffalo.—A single specimen taken on the lower Sangamon River. FR 1 (Sangamon).

Ictiobus cyprinellus (Valenciennes). Bigmouth buffalo.—One specimen reported from the lower Sangamon. TH 1 (Sangamon).

Ictiobus niger (Rafinesque). Black buffalo.—Reported as *Ictiobus urus* by Thompson & Hunt and known in the county by a single specimen taken on the lower Sangamon River. TH 1 (Sangamon).

Minytrema melanops (Rafinesque). Spotted sucker.—FR 15 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 4 (not 5 as stated: Kaskaskia, Salt Fork), LS 1 (Little Vermilion).

Moxostoma anisurum (Rafinesque). Silver redhorse.—TH 1 (Sangamon), LS 7 (Salt Fork, Sangamon).

Moxostoma macrolepidotum macrolepidotum (Le Sueur). Northern redhorse.—Reported as *Moxostoma breviceps* by Forbes & Richardson, Thompson & Hunt, and other early authors, but later and until very recently called *M. aureolum*. FR 1 (Salt Fork), TH 6 (Kaskaskia, Sangamon), LS 8 (Sangamon).

Moxostoma erythrurum (Rafinesque). Golden redhorse.—Reported as *Moxostoma aureolum* by Forbes & Richardson, Thompson & Hunt, and other early authors, who presumably based their identifications on specimens of this species. The superficially similar *M. duquesnei*, which the early authors did not distinguish from *erythrurum*, was not taken in the county during the 1959 survey and is not represented among the Forbes & Richardson and Thompson & Hunt collections still extant. FR 11 (Salt Fork, Middle Fork, Sangamon), TH 22 (all drainages except Little Vermilion), LS 28 (Embarrass, Salt Fork, Middle Fork, Sangamon).

Cyprinidae

Campostoma anomalum pullum (Agassiz). Central stoneroller.—Reported as *Campostoma anomalum* by Forbes & Richardson, Thompson & Hunt, and other early authors. This fish is assignable to the subspecies *C. a. pullum*. FR 17 (Salt

Fork, Middle Fork, Sangamon), TH 64 (all drainages except Little Vermilion), LS 102 (all drainages except Little Vermilion).

Carassius auratus (Linnaeus). Goldfish.—Several large specimens taken by rowboat shocker from Kaufman's Clear Lake, where they had been introduced. Another adult was found in the Salt Fork near Homer in 1955. LS 2 (Kaskaskia, Salt Fork).

Cyprinus carpio Linnaeus. Carp.—FR 4 (Salt Fork, Middle Fork, Sangamon), TH 11 (not 9 as stated: Embarrass, Salt Fork, Sangamon), LS 56 (all drainages).

Ericymba buccata Cope. Silverjaw minnow.—FR 22 (Kaskaskia, Salt Fork, Embarrass, Middle Fork), TH 79 (all drainages), LS 78 (all drainages except Little Vermilion).

Hybognathus nuchalis nuchalis Agassiz. Western silvery minnow.—FR 4 (Salt Fork, Middle Fork, Sangamon), TH 9 (Kaskaskia), LS 9 (Kaskaskia).

Hybopsis aestivalis hyostoma (Gilbert). Ohio speckled chub.—Reported from the Middle Fork on the Champaign-Ford county line as *Hybopsis hyostomus* by Large (1903:19). The locality, which is far removed from other records of the species, was either ignored or overlooked by Forbes & Richardson and Thompson & Hunt; inasmuch as Large's specimen is not extant for reidentification and additional specimens have never been taken, the record is open to doubt.

Hybopsis amblops amblops (Rafinesque). Northern bigeye chub.—FR 6 (Salt Fork, Middle Fork), TH 8 (Embarrass, Salt Fork, Middle Fork).

Hybopsis biguttata (Kirtland). Hornyhead chub.—Reported as *Hybopsis kentuckiensis* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 10 (Salt Fork, Middle Fork, Sangamon), TH 46 (Kaskaskia, Middle Fork, Sangamon), LS 70 (Kaskaskia, Salt Fork, Middle Fork, Sangamon).

Hybopsis storeriana (Kirtland). Silver chub.—A specimen from the Middle Fork reported by Forbes & Richardson. A second specimen, an individual 4.5 inches long taken on a hook in the Salt Fork River near Homer in July, 1952, was reported to us by Dr. Marcus S. Goldman. FR 1 (Middle Fork), LS 1 (Salt Fork).

Notemigonus crysoleucas (Mitchill). Golden shiner.—Reported as *Abramis crysoleucas* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 20 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 41 (all drainages), LS 46 (all drainages).

Notropis amnis amnis Hubbs & Greene. Northern pallid shiner.—Specimens of this species referred by Thompson & Hunt (on different pages) to *Notropis heterolepis*, *N. cayuga*, and *N. c. atrocaudalis*. One of their specimens was subsequently designated as a paratype of the new species *amnis*. A re-examination of the Thompson & Hunt specimens of "*Notropis blennius*" still extant has revealed specimens of *amnis* mixed with *N. stramineus* from three stations on the Sangamon near Fisher. TH 3 (Sangamon).

Notropis atherinoides atherinoides Rafinesque. Common emerald shiner.—FR 2 (Salt Fork, Sangamon), LS 2 (Embarass, Salt Fork).

Notropis boops Gilbert. Bigeye shiner.—Reported as *Notropis illecebrosus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 1 (Salt Fork), TH 2 (Middle Fork).

Notropis chrysocephalus (Rafinesque). Central common shiner.—Reported as *Notropis cornutus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 9 (Salt Fork, Sangamon), TH 54 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), LS 64 (all drainages except Little Vermilion).

Notropis dorsalis dorsalis (Agassiz). Central bigmouth shiner.—Reported as *Notropis gilberti* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 1 (Salt Fork), TH 5 (Sangamon), LS 28 (Kaskaskia, Middle Fork, Sangamon).

Notropis heterolepis Eigenmann & Eigenmann. Blacknose shiner.—Reported as *Notropis cayuga* and *N. c. atrocaudalis* by Forbes & Richardson. Their records for the Salt Fork and Sangamon drainages presumably refer only to the blacknose shiner. The species may have disappeared from the county when the prairie sloughs and natural lakes were drained. The specimens assigned to *N. heterolepis* by Thompson & Hunt is actually *N. amnis amnis*. FR 2 (Salt Fork, Sangamon).

Notropis lutrensis (Baird & Girard). Red shiner.—A species appearing in the county since 1928. It is now abundant in the Kaskaskia and upper Sangamon drainages in a variety of river and creek habitats. LS 21 (Kaskaskia, Sangamon).

Notropis rubellus (Agassiz). Rosyface shiner.—Misidentified as "*Notropis atherinoides*, var." by Thompson & Hunt. Our collections from the same stations contain *rubellus* and not *atherinoides*. Of the three Thompson & Hunt collections labeled *atherinoides*, the one extant contains *rubellus* only. TH 3 (Middle Fork), LS 6 (Middle Fork).

Notropis spilopterus spilopterus (Cope) × *hypsisomatus* Gibbs. Spotfin shiner.—Included in the composite *Notropis whippelii* of Forbes & Richardson, Thompson & Hunt, and other early authors. Of the 53 collections of "*N. whippelii*" reported by Thompson & Hunt, 34 are still extant and have been reidentified. Thirty-two of these contain spotfin shiners. Material from the eastern side of the county (Salt Fork and Middle Fork) is assignable to the nominate subspecies on the basis of both lateral-line scale counts and body shape, specimens from the Kaskaskia (western side) are apparently typical *hypsisomatus* in both characters, and specimens from the Sangamon (western side) have nearly typical lateral-line scale counts of *hypsisomatus* but are intermediate between *spilopterus* and *hypsisomatus* in body shape. FR ?, TH 32 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), LS 63 (all drainages).

Notropis stramineus (Cope). Sand shiner.—Included in the composite *Notropis blennius* of Forbes & Richardson, Thompson & Hunt, and other early authors, but until recently called *N. deliciosus*. The identity of the Forbes & Richardson specimens is not known, but probably the majority belong to this species. Of the 44 collections of "*blennius*" reported by Thompson & Hunt, 32 are still extant and have been reidentified, revealing *stramineus* exclusively, or in part, in all of them. FR ?, TH 32 (all drainages except Little Vermilion), LS 93 (all drainages).

Notropis umbratilis cyanocephalus (Copeland). Redfin shiner.—Reported as *Notropis umbratilis atripes* by Forbes &

Richardson, Thompson & Hunt, and other early authors. Local populations are extremely variable, and subspecific identification is based on geographical grounds. FR 8 (Salt Fork, Sangamon), TH 69 (all drainages), LS 97 (all drainages).

Notropis volucellus volucellus (Cope). Northern mimic shiner.—Probably included in the composite *Notropis blennius* of Forbes & Richardson and found in 2 collections (representing two localities) in the 32 reidentified collections still extant of Thompson & Hunt's "*N. blennius*." FR ?, TH 2 (Middle Fork), LS 3 (Middle Fork, Sangamon).

Notropis whipplei (Girard). Steelcolor shiner.—Probably included in the composite *Notropis whippilii* of Forbes & Richardson and found at 16 localities in the 34 reidentified collections of Thompson & Hunt's "*whippilii*." FR ?, TH 16 (Kaskaskia, Embarrass, Salt Fork, Middle Fork, Sangamon), LS 27 (Embarrass, Salt Fork, Middle Fork, Sangamon).

Opsopoeodus emiliae Hay. Pugnose minnow.—A specimen from the Salt Fork reported by Large (1903:15). TH 2 (Kaskaskia; 1 reported from a tributary and another found among a series of Thompson & Hunt's "*Notropis blennius*" from the Kaskaskia proper).

Phenacobius mirabilis (Girard). Suckermouth minnow.—FR 18 (Kaskaskia, Embarrass, Salt Fork, Sangamon), TH 25 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), LS 34 (all drainages except Little Vermilion).

Pimephales notatus (Rafinesque). Bluntnose minnow.—FR 37 (all drainages except Little Vermilion), TH 111 (all drainages), LS 134 (all drainages).

Pimephales promelas promelas Rafinesque. Northern fathead minnow.—FR 4 (Sangamon), TH 19 (Sangamon), LS 20 (Sangamon, Kaskaskia).

Pimephales vigilax perspicuus (Girard). Northern bullhead minnow.—Reported as *Cliola vigilax* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 6 (Sangamon), TH 4 (Salt Fork, Sangamon).

Semotilus atromaculatus atromaculatus (Mitchill). Northern creek chub.—FR 9 (Salt Fork, Middle Fork, Sangamon), TH 101 (all drainages), LS 126 (all drainages).

Ictaluridae

Ictalurus melas (Rafinesque). Black bullhead.—Reported as *Ameiurus melas* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 12 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 12 (not 13 as stated: all drainages except Middle Fork), LS 7 (all drainages except Middle Fork).

Ictalurus natalis (Le Sueur). Yellow bullhead.—Reported as *Ameiurus natalis* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 6 (Kaskaskia, Salt Fork), TH 15 (all drainages except Embarrass), LS 38 (all drainages).

Ictalurus nebulosus (Le Sueur). Brown bullhead.—Taken only from Franzen's Fishing Lake. Many specimens of this species were introduced into this lake for sport fishing during the course of our survey. LS 1 (Salt Fork).

Ictalurus punctatus (Rafinesque). Channel catfish.—FR 4 (Salt Fork, Middle Fork, Sangamon), TH 11 (not 8 as stated: Salt Fork, Sangamon), LS 17 (Salt Fork, Sangamon, Middle Fork).

Noturus exilis Nelson. Slender madtom.—Reported as *Schilbeodes exilis* by Thompson & Hunt. TH 2 (Middle Fork, Sangamon).

Noturus flavus Rafinesque. Stonecat.—FR 1 (Sangamon), TH 5 (Salt Fork, Middle Fork, Sangamon), LS 22 (Salt Fork, Middle Fork, Sangamon).

Noturus gyrinus (Mitchill). Tadpole madtom.—Reported as *Schilbeodes gyrinus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 13 (Kaskaskia, Salt Fork, Sangamon), TH 8 (not 7 as stated: Salt Fork), LS 18 (Kaskaskia, Salt Fork, Sangamon).

Noturus miurus Jordan. Brindled madtom.—Reported as *Schilbeodes miurus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 2 (Salt Fork), TH 2 (not 1 as stated: Salt Fork), LS 8 (Embarrass, Salt Fork, Middle Fork).

Noturus nocturnus Jordan & Gilbert. Freckled madtom.—A specimen seined from a pool over mixed sand-gravel and another from a fast riffle in the middle Sangamon River. LS 2 (Sangamon).

Pylodictis olivaris (Rafinesque). Flathead catfish.—Reported as *Leptops olivar-*

is by Thompson & Hunt. TH 1 (Sangamon), LS 4 (Middle Fork, Salt Fork, Sangamon). The flathead is probably much more common than the available records indicate.

Anguillidae

Anguilla rostrata (Le Sueur). American eel.—Reported as *Anguilla chrysypa* by Thompson & Hunt on the basis of a specimen caught by a fisherman in the Embarrass River near Villa Grove just south of the Champaign County line. Dr. Marcus S. Goldman informs us that a specimen was taken on baited hook in the lower Sangamon River about 1940. In the spring of 1961, two eels were taken by hook-and-line fishermen from a small land-locked lake near Mahomet. We subsequently learned that these fish, originally from the Wabash River, escaped from the creel of a local fisherman. TH 1 (Embarrass), LS 1 (Sangamon).

Cyprinodontidae

Fundulus notatus (Rafinesque). Black-stripe topminnow.—FR 14 (Kaskaskia, Embarrass, Salt Fork, Sangamon), TH 41 (not 43 as stated: all drainages), LS 54 (all drainages).

Poeciliidae

Gambusia affinis affinis (Baird & Girard). Western mosquitofish.—A recent arrival in the county. LS 2 (Salt Fork).

Atherinidae

Labidesthes sicculus (Cope). Brook silverside.—FR 6 (Salt Fork, Sangamon), TH 5 (not 3 as stated: Salt Fork), LS 3 (Salt Fork).

Aphredoderidae

Aphredoderus sayanus (Gilliams). Pi-rateperch.—FR 1 (Sangamon), TH 12 (Kaskaskia, Embarrass, Sangamon), LS 13 (Kaskaskia, Embarrass, Sangamon).

Serranidae

Roccus mississippiensis (Jordan & Eigenmann). Yellow bass.—Now known in this county only in Kaufman's Clear Lake and Lake-of-the-Woods, where it has been introduced. The evidence indicates that the yellow bass held a brief tenure in the Sangamon River of Cham-

paign County from 1955 to 1958. Dr. Marcus S. Goldman has numerous yellow bass records for the Sangamon for 1955, and we took specimens there in November of 1957. The Sangamon River fish presumably came from the Lake Decatur population. LS 3 (Kaskaskia, Sangamon).

Centrarchidae

Ambloplites rupestris rupestris (Rafinesque). Northern rock bass.—TH 1 (Salt Fork), LS 16 (Salt Fork, Middle Fork, Sangamon).

Chaenobryttus gulosus (Cuvier). Warmouth.—A specimen taken by us on the Sangamon near Mahomet in November, 1957. Dr. Marcus S. Goldman reports that he has taken the species on hook and line in the same area. FR 3 (Kaskaskia), TH 1 (Salt Fork), LS 1 (Sangamon).

Lepomis cyanellus Rafinesque. Green sunfish.—FR 23 (all drainages except Little Vermilion), TH 38 (all drainages), LS 75 (all drainages except Little Vermilion).

Lepomis humilis (Girard). Orange-spotted sunfish.—FR 16 (Kaskaskia, Salt Fork, Middle Fork, Sangamon), TH 13 (Salt Fork, Middle Fork, Sangamon), LS 9 (Salt Fork, Middle Fork, Sangamon).

Lepomis macrochirus macrochirus Rafinesque. Northern bluegill.—Reported as *Lepomis pallidus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 2 (Salt Fork, Sangamon), TH 1 (Salt Fork), LS 16 (Kaskaskia, Salt Fork, Sangamon).

Lepomis megalotis megalotis (Rafinesque). Central longear sunfish.—FR 16 (Kaskaskia, Salt Fork, Middle Fork), TH 37 (not 39 as stated: all drainages), LS 44 (all drainages).

Lepomis microlophus (Günther). Red-ear sunfish.—Formerly known as *Eupomotis heros*. The widely transplanted red-ear is a recent arrival in Champaign County. Dr. Marcus S. Goldman recalls catching the species in the Sangamon near the Champaign-Piatt county line in the summer of 1958. LS 1 (Kaskaskia).

Lepomis punctatus miniatus Jordan. Spotted sunfish.—A specimen taken from the outlet of Crystal Lake by Thompson & Hunt and reported as *Lepomis miniatus* (Garman's sunfish). Their specimen is no longer extant. TH 1 (Salt Fork).

Micropterus dolomieu dolomieu Lacépède. Northern smallmouth bass.—FR 1 (Salt Fork), TH 16 (Salt Fork, Middle Fork, Sangamon), LS 37 (Kaskaskia, Salt Fork, Middle Fork, Sangamon).

Micropterus punctulatus punctulatus (Rafinesque). Northern spotted bass.—Probably included in the composite *Micropterus salmoides* of Forbes & Richardson, Thompson & Hunt, and other early authors. Their specimens of "*salmoides*" are not available for re-examination. FR ?, TH ?, LS 9 (Salt Fork, Middle Fork).

Micropterus salmoides salmoides (Lacépède). Northern largemouth bass.—Probably included in the composite *Micropterus salmoides* of Forbes & Richardson, Thompson & Hunt, and other early authors. Their specimens are no longer extant. FR ?, TH ?, LS 14 (Salt Fork, Middle Fork, Sangamon).

Pomoxis annularis Rafinesque. White crappie.—FR 4 (Embarrass, Salt Fork, Sangamon), TH 2 (Sangamon), LS 16 (Kaskaskia, Salt Fork, Middle Fork, Sangamon).

Pomoxis nigromaculatus (Le Sueur). Black crappie.—Reported as *Pomoxis sparoides* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 7 (Kaskaskia, Salt Fork, Sangamon), TH 3 (Sangamon), LS 2 (Salt Fork, Sangamon).

Percidae

Ammocrypta pellucida (Baird). Eastern sand darter.—TH 2 (Middle Fork), LS 3 (Middle Fork).

Etheostoma asprigene (Forbes). Mud darter.—Reported as *Etheostoma jessiae* by Forbes & Richardson. FR 2 (not 1 as stated by Thompson & Hunt: Salt Fork and Sangamon), LS 1 (Sangamon).

Etheostoma blennioides Rafinesque. Greenside darter.—Reported as *Diplesion blennioides* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 7 (Salt Fork), TH 10 (Embarrass, Salt Fork, Middle Fork), LS 13 (Embarrass, Little Vermilion, Salt Fork, Middle Fork).

Etheostoma caeruleum Storer. Rainbow darter.—Probably included in the composite *Etheostoma caeruleum* of Forbes & Richardson; seven localities represented among the 11 Thompson & Hunt collec-

tions still extant. FR ?, TH 7 (Embarrass, Salt Fork, Middle Fork), LS 7 (Kaskaskia, Embarrass, Salt Fork, Middle Fork).

Etheostoma chlorosomum (Hay). Bluntnose darter.—Reported as *Boleosoma camurum* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 1 (Sangamon), TH 1 (Kaskaskia).

Etheostoma flabellare flabellare (Rafinesque) $\times$ *lineolatum* (Agassiz). Fantail darter.—Champaign County specimens representing an intergrade population. Material from the Sangamon is rather distinctly striped and approaches typical *lineolatum*, whereas *flabellare* influence predominates in our series from the Salt Fork drainage. Specimens from the other drainage systems are intermediate in pattern. FR 2 (Salt Fork), TH 16 (not 14 as stated: Embarrass, Salt Fork, Middle Fork, Sangamon), LS 18 (Salt Fork, Middle Fork, Sangamon).

Etheostoma gracile (Girard). Slough darter.—Reported as *Boleichthys fusiformis* by Thompson & Hunt and known in the county from only one specimen, still extant, taken on lower Wildcat Slough. TH 1 (Sangamon).

Etheostoma nigrum nigrum (Rafinesque). Eastern Johnny darter.—Reported as *Boleosoma nigrum* by Forbes & Richardson, Thompson & Hunt, and other early authors. We assign the Champaign County material to the nominate subspecies on geographical grounds. Material from the Embarrass, Little Vermilion, and perhaps the Kaskaskia is clearly referable to *Etheostoma nigrum nigrum*, but large series from the Sangamon, Salt Fork, and Middle Fork exhibit characters of both *E. n. nigrum* and *E. n. eulepis* Hubbs & Greene, and specimens from the Salt Fork and Middle Fork of the Vermilion display predominantly *eulepis* characters. FR 19 (Embarrass, Salt Fork, Sangamon), TH 82 (all drainages), LS 80 (all drainages).

Etheostoma spectabile spectabile (Agassiz). Northern orangethroat darter.—Probably included in the composite *Etheostoma coeruleum* of Forbes & Richardson and found in 4 of the 11 Thompson & Hunt collections still extant. FR ?, TH 4 (Sangamon), LS 60 (all drainages).

Etheostoma zonale zonale (Cope). Eastern banded darter.—TH 8 (Sangamon), LS 6 (Sangamon).

Percina caprodes caprodes (Rafinesque) × *semifasciata* (De Kay). Logperch.—The meager material available regarded as representing an intergrade population. Middle Fork specimens show greater resemblance to *Percina caprodes semifasciata* and Kaskaskia specimens to *P. c. caprodes*; Sangamon specimens are almost exactly intermediate. FR 2 (Salt Fork, Sangamon), TH 2 (Kaskaskia, Middle Fork), LS 10 (all drainages except the Salt Fork).

Percina maculata (Girard). Blackside darter.—Reported as *Hadropterus aspro* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 15 (Salt Fork, Sangamon), TH 24 (all drainages except Little Vermilion), LS 49 (all drainages except Little Vermilion).

Percina phoxocephala (Nelson). Slenderhead darter.—Reported as *Hadropterus phoxocephalus* by Forbes & Richardson, Thompson & Hunt, and other early authors. FR 3 (Salt Fork, Sangamon), TH 8 (Salt Fork, Middle Fork, Sangamon), LS 18 (Salt Fork, Middle Fork, Sangamon).

Percina sciera sciera (Swain). Northern dusky darter.—A specimen recently taken in the minnow seine near Penfield, the first record for the county. LS 1 (Middle Fork).

Sciaenidae

Aplodinotus grunniens Rafinesque. Freshwater drum.—TH 3 (Sangamon), LS 4 (Sangamon).

ANALYSIS OF DISTRIBUTION PATTERNS

Of the 90 species of fishes in our annotated list for Champaign County, 7 (*Amia calva*, *Carassius auratus*, *Ictalurus nebulosus*, *Gambusia affinis*, *Roccus mississippiensis*, *Lepomis punctatus*, and *Lepomis microlophus*) are introductions and must be excluded from any distributional analysis of native species.

Of the remaining 83 species, 13 reach the edges of their natural ranges within, or very near, Champaign County. They can be classified as northern, southern,

western, and eastern components on the basis of the direction in which their main ranges are located in relation to the county. *Notropis rubellus* and *Etheostoma zonale* are northern species that, in Illinois, reach their southernmost point of distribution within the county. *Notropis heterolepis* also is a northern species that once extended southward somewhat below Champaign County, but whose range has since retreated to the north. *Noturus nocturnus*, *Micropterus punctulatus*, and *Etheostoma gracile* are southern species that, in Illinois, have their northernmost records of occurrence within the county. *Notropis dorsalis*, *Notropis lutrensis*, and *Noturus exilis* are western species that, in Illinois, reach their easternmost limit of distribution in the county. *Noturus miurus*, *Etheostoma blennioides*, and *Hybopsis amblops* are eastern species that, at least at this latitude, reach their westernmost limit of distribution in the county. *Eriocymba buccata*, another eastern species, occurs throughout Champaign County but does not occur, in central Illinois, much to the west of our area. Peripheral populations are of considerable interest in that they can, when studied over a period of time, provide evidence of range expansion and withdrawal. The 13 species just mentioned above have been carefully studied for such trends, and the data that they provide are discussed under Changes in Distribution.

The other 70 species of fishes in our Champaign County list have more extensive ranges and occur throughout this part of the state. These 70 species, needless to say, do not occur everywhere in the county. In fact, only 19 species are known to occur in all six drainages within the county. These species are as follows:

Esox americanus
Catostomus commersoni
Erimyzon oblongus
Cyprinus carpio
Eriocymba buccata
Notemigonus crysoleucas
Notropis spilopterus
Notropis stramineus
Notropis umbratilis
Pimephales notatus
Semotilus atromaculatus
Ictalurus melas
Ictalurus natalis

Fundulus notatus
Lepomis cyanellus
Lepomis megalotis
Etheostoma nigrum
Etheostoma spectabile
Percina caprodes

Certain additional species, such as *Lepomis macrochirus* and *Micropterus salmoides*, are known to be in many ponds in all parts of the county, having been introduced for sport fishing, but they were not taken in all drainages as regular components of the stream populations.

Some species could be expected to show seasonal differences in occurrence, as several of our drainages are represented by headwaters only. For example, some of the catostomids might have been present in headwaters during the spring months but might have migrated downstream and out of the county before our summer field work began. Although our data on seasonal distribution are limited, we found no evidence to support the assumption that spring runs of migratory species greatly influence the occurrence of species in Champaign County. We revisited approximately 20 stations in the county one or more times, the revisits representing the months of September, October, January, May, June, and July. Subsequent visits to a station usually revealed a few species that we missed on the initial visit, but at every station the greatest number of species was taken on the first visit, probably because the low water levels in July and August of 1959 had concentrated the fishes. Moreover, the species added on subsequent visits were usually fishes of relatively sedentary habits rather than strongly migratory species such as catostomids.

CHANGES IN DISTRIBUTION

The earliest published references to Champaign County fishes appear to be those of Large (1903:19, 15), who cited *Hybopsis hyostomus* (equals *H. aestivalis*) and *Opsopoeodus* [sic] *megalops* (equals *Opsopoeodus emiliae*) from specific localities within the county. No date or other information is given, but the collections are presumed to have been made prior to the extensive work of Forbes & Richardson. Both records, although published in 1903, were overlooked, or perhaps ig-

nored, by Forbes & Richardson (1908) and all subsequent authors. The specimens are no longer extant.

Although fish collections by staff members of the Illinois State Laboratory of Natural History, a parent agency of the Natural History Survey, were made as early as 1882, no references to Champaign County fishes, except those by Large (1903:15, 19), appeared until Forbes (1907) published a paper on the distribution of certain Illinois fishes.

Forbes & Richardson Records

The Forbes & Richardson distributional records were plotted on the maps in an atlas accompanying *The Fishes of Illinois* or were cited in the text. Although fish nomenclature of 1908 differs markedly from that of today, we are virtually certain that the following species as now recognized were included in the 48 collections of Forbes & Richardson:

Dorosoma cepedianum
Esox americanus
Carpiodes cyprinus
Carpiodes velifer
Catostomus commersoni
Erimyzon oblongus
Hypentelium nigricans
Ictiobus bubalus
Mintytrema melanops
Moxostoma macrolepidotum
Moxostoma erythrurum
Campostoma anomalum
Cyprinus carpio
Ericymba buccata
Hybognathus nuchalis
Hybopsis amblops
Hybopsis biguttata
Hybopsis storeriana
Notemigonus crysoleucas
Notropis atherinoides
Notropis boops
Notropis chrysocephalus
Notropis dorsalis
Notropis heterolepis
Notropis umbratilis
Phenacobius mirabilis
Pimephales notatus
Pimephales promelas
Pimephales vigilax
Semotilus atromaculatus
Ictalurus melas
Ictalurus natalis
Ictalurus punctatus

Noturus flavus
Noturus gyrinus
Noturus miurus
Fundulus notatus
Labidesthes sicculus
Aphredoderus sayanus
Chaenobryttus gulosus
Lepomis cyanellus
Lepomis humilis
Lepomis macrochirus
Lepomis megalotis
Micropterus dolomieu
Pomoxis annularis
Pomoxis nigromaculatus
Etheostoma asprigene
Etheostoma blennioides
Etheostoma chlorosomum
Etheostoma flabellare
Etheostoma nigrum
Percina caprodes
Percina maculata
Percina phoxocephala

In addition to the species cited above are probably others. Forbes & Richardson's nominal "*Notropis blennius*" was probably a composite of *N. stramineus* and *N. volucellus*, their "*Notropis whippeli*" a composite of *N. spilopterus* and *N. whipplei*, their "*Micropterus salmoides*" a composite of *M. punctulatus* and *M. salmoides*, and their "*Etheostoma coeruleum*" a composite of *E. caeruleum* and *E. spectabile*. Although many of the early collections have been lost and cannot be reidentified, we are reasonably certain that 63 species were represented in the collections of Forbes & Richardson and that the 2 other species reported previously by Large (1903:15, 19) bring the total number of species collected in the county by 1901 to 65.

Thompson & Hunt Records

Although the material of Forbes & Richardson was cited in various revisionary studies published between 1901 and 1928, no additional Champaign County records for this period were published in these taxonomic papers.

Thompson & Hunt, in their 1930 publication, chose to use the nomenclature of Forbes & Richardson, and many of their nominal species would have been difficult to assign had we not had much of their material for reidentification. They claimed the addition of 13 species to the known fauna of Champaign County, but restudy

of their specimens indicated that they actually added the following 15:

Hiodon alosoides
Ictiobus cyprinellus
Ictiobus niger
Moxostoma anisurum
Notropis amnis
Notropis rubellus
Noturus exilis
Pylodictis olivaris
Ambloplites rupestris
Lepomis punctatus
 (probably introduced)
Anquilla rostrata
 (from adjacent Douglas County)
Ammocrypta pellucida
Etheostoma gracile
Etheostoma zonale
Aplodinotus grunniens

Their nominal "*Notropis blennius*" included both *N. stramineus* and *N. volucellus*; their "*Notropis whippeli*," both *N. spilopterus* and *N. whipplei*; and their "*Etheostoma coeruleum*," both *E. caeruleum* and *E. spectabile*. Whether their "*Micropterus salmoides*" also included *M. punctulatus* is not known, as the specimens have been lost.

Thompson & Hunt believed that they missed only three species that had been previously recorded from the county, whereas they actually failed to rediscover the following six:

Ictiobus bubalus
Hybopsis aestivalis
Hybopsis storeriana
Notropis atherinoides
Notropis heterolepis
Etheostoma asprigene

The discrepancy is due to their apparent misidentification of *Notropis atherinoides* and their failure to include the two species recorded by Large (1903:15, 19). In all, Thompson & Hunt obtained 74 species, 59 of which had been recorded previously from the county.

Almost half of the species recorded by both Forbes & Richardson and Thompson & Hunt showed an increase in number of stations and in number of drainages occupied in the approximately 30-year period between the surveys. Many of the apparent increases in abundance are of doubtful significance because of the more intensive collecting program of Thompson & Hunt; however, some of the apparent

increases in abundance appear to be significant, as will be shown later. Thompson & Hunt believed that their data indicated a pronounced increase in the abundance and distribution of *Semotilus atromaculatus*, *Ericymba buccata*, and *Micropterus dolomieu* and suggested the recent arrival in the county of *Aplodinotus grunniens*.

A number of species showed apparent decreases in abundance and distribution. Some of the apparent decreases were probably the result of cyclic changes in populations; others probably represent gradual disappearance of species. Thompson & Hunt cited *Hybognathus nuchalis* and *Minytrema melanops* specifically and noted that several other species seemed to have declined in abundance. Comparison of the distribution maps of Forbes & Richardson and those of Thompson & Hunt suggests that a reduction in numbers of stations represented, in numbers of drainages occupied, or in numbers of both, also occurred in the following species: *Dorosoma cepedianum*, *Carpionodes cyprinus*, *C. velifer*, and *Moxostoma macrolepidotum*. However, in these species the apparent decrease in abundance and distribution was probably not real, as there was no evidence of their decrease from 1928 to 1959. Moreover, all are large fishes characteristic of deep pools and can be easily missed when collecting is done principally with a 10-foot minnow seine. Another group of fishes, all of which are creek species of small size, also showed some reduction in numbers of stations or drainages occupied, or both; but their apparent reduction is assumed to have been due to only a temporary decline in their populations about 1928, as in 1959 none showed evidence of reduced occurrence. A third group of species, to be cited later, showed striking decrease in abundance and distribution between 1901 and 1928. Their continued decline is documented by more recent data.

Investigations Between 1929 and 1959

Although some observations on fishes of Champaign County were made between 1929 and 1959 by various fishermen and by personnel of the Illinois Natural History Survey and the University of Illinois, no records of unusual interest were pub-

lished. Several of Thompson & Hunt's records were cited by Luce (1933), who utilized their collections from the headwaters of the Kaskaskia in his study of that river, and by O'Donnell (1935) in his list of Illinois fishes. During the next several years, material from Champaign County was cited in several revisionary studies, but none of these contributed new distributional information. Although no concerted effort was made to obtain collections from the county, occasional field work by two University of Illinois biologists, the late H. J. Van Cleave and H. H. Shoemaker, and by ecology classes at the University contributed to the knowledge of local fishes. Personnel of the Natural History Survey, with headquarters in the center of the county, have been alert to major changes in field populations and to alterations of habitats in the area; they have supplemented their own observations through contacts with fishermen and other local observers.

Recent Survey Records

Collections in 1959, and subsequently, added 10 species to the known fauna of Champaign County. Six of these (*Amia calva*, *Carassius auratus*, *Ictalurus nebulosus*, *Gambusia affinis*, *Roccus mississippiensis*, and *Lepomis microlophus*) are known to be introduced species; three (*Lepisosteus osseus*, *Noturus nocturnus*, and *Percina sciera*) are native and presumably were always present but were overlooked by previous investigators; one (*Notropis lutrensis*) recently extended its range eastward into Champaign County. Our collections failed to reveal the presence of 11 species that were taken 30 years before by Thompson & Hunt:

Ictiobus cyprinellus
Ictiobus niger
Hybopsis amblops
Notropis amnis
Notropis boops
Opsopoeodus emiliae
Pimephales vigilax
Noturus exilis
Lepomis punctatus
Etheostoma chlorosomum
Etheostoma gracile

Our collections also failed to include three species (*Ictiobus bubalus*, *Hybopsis aestivalis*, and *Notropis heterolepis*) taken

Table 6.—Summary of collections and the number of species taken and recorded in Champaign County by various collectors. Figures in parentheses indicate the numbers of collecting stations.

OCCURRENCE CATEGORY	PRE-FORBES & RICHARDSON (?)	FORBES & RICHARDSON (48)	THOMPSON & HUNT (126)	LARIMORE & SMITH (152)
Number of species taken.....	2	63	74	74
Number of previously unrecorded species taken.....	2	63	15	10
Number of previously recorded species retaken.....	0	0	59	64
Number of previously recorded species not taken.....	0	2	6	16
Total number of species recorded (cumulative).....	2	65	80	90

in the county 60 or more years ago by Forbes & Richardson or by Large. Two species (*N. atherinoides* and *Etheostoma asprigene*) taken by Forbes & Richardson, but not by Thompson & Hunt, were re-discovered in the county in 1959. In all, our collections represented 74 species, 64 of which had been previously reported from Champaign County. The number of collecting stations, number of species represented, and other data for each survey are summarized in table 6.

Summary of Changes Over
60-Year Period

With full realization that fish populations may vary from one year to the next and that comparison of results of three widely spaced surveys could thus lead to erroneous inferences, we believe that certain changes are demonstrable in the Champaign County fish fauna over the period of study reported here. (In this paper, occurrence of a species is measured in relation to both the number of localities or stations represented and the number of drainages in which it was found.)

Evidence provided by the three surveys reveals numerous changes in occurrence of the fish fauna of the county. Of the 9 species added in 1959, at least 1 (*Notropis lutrensis*) appeared to have dispersed naturally from the west, and 15 species, which presumably had always been present in the county, showed increases in abundance and in number of drainages occupied. These 16 species, the percentage of

stations in which they occurred, and the number of drainage systems in which they were found in each survey are listed in table 7. Increased occurrence of these 16 species is suggested by scrutiny of the distribution maps, figs. 15–70, pages 362–75.

On the basis of table 7, we could assume that the large fishes (*Pylodictis olivaris*, both species of *Moxostoma*, *Micropterus dolomieu*, and *Cyprinus carpio*) appeared to be more common in 1959 than formerly because the modern collecting apparatus used was more efficient than seines in sampling deep pools. Improved sampling methods could conceivably explain the slight increases in occurrence shown for *P. olivaris*, the two species of *Moxostoma*, and part of the increase in occurrence shown for *C. carpio*, which is easily shocked.

It has been suggested that the mushrooming of *Cyprinus carpio* populations within the past 30 years could be associated with the increased water pollution in the same period. Perusal of the list of species in table 7 reveals that the two other pollution-tolerant fishes, *Notropis umbratilis* and *Semotilus atromaculatus*, showed only modest increases in abundance in this period but that their great increase in abundance occurred much earlier, some time between 1899 and 1928. Moreover, gains of equal magnitude can be observed in such pollution-intolerant species as *N. rubellus* and *Hypentelium nigricans*.

Notropis rubellus, *N. dorsalis*, and *N. lutrensis* are of particular interest because

Table 7.—Species showing increases in frequency of occurrence (per cent of stations in which each species was taken) in Champaign County in three surveys; for each species is given the number of drainages in which it was taken in each survey.

SPECIES	FORBES & RICHARDSON		THOMPSON & HUNT		LARIMORE & SMITH	
	Per Cent of Stations	Number of Drainages	Per Cent of Stations	Number of Drainages	Per Cent of Stations	Number of Drainages
<i>Notropis lutrensis</i>	0	0	0.0	0	13.8	2
<i>Ambloplites rupestris</i>	0	0	0.8	1	10.5	3
<i>Moxostoma anisurum</i>	0	0	0.8	1	4.6	2
<i>Pylodictis olivaris</i>	0	0	0.8	1	2.6	3
<i>Notropis rubellus</i>	0	0	2.4	1	3.9	1
<i>Noturus flavus</i>	2.1	1	4.0	3	14.5	3
<i>Notropis dorsalis</i>	2.1	1	4.0	1	18.4	3
<i>Moxostoma</i>						
<i>macrolepidotum</i>	2.1	1	4.8	2	5.3	1
<i>Micropterus dolomieu</i>	2.1	1	12.7	3	24.3	4
<i>Cyprinus carpio</i>	8.3	3	8.6	3	36.8	6
<i>Hypentelium nigricans</i>	14.6	3	21.4	5	27.6	5
<i>Notropis umbratilis</i>	16.7	2	54.8	6	63.8	6
<i>Semotilus atromaculatus</i>	18.7	3	80.1	6	83.0	6
<i>Notropis chrysocephalus</i>	18.7	2	42.9	4	52.0	5
<i>Hybopsis biguttata</i>	20.8	3	36.5	3	46.0	4
<i>Campostoma anomalum</i>	35.4	3	50.8	5	67.1	5

they are peripheral populations, *N. rubellus* reaching its southernmost point of distribution, at least in eastern Illinois, within Champaign County, and the other two reaching their easternmost limits of distribution in the county. *N. rubellus* appears to have extended its range southward into the county between 1899 and

1928 and to have replaced the allied *N. atherinoides* in both drainages where *rubellus* was found in 1959. *N. dorsalis* has been known in the county for at least 60 years; there is evidence from another source, in addition to the Champaign County data, that its range is gradually shifting eastward. A similar trend is

Table 8.—Species showing decreases in frequency of occurrence (per cent of stations in which each species was taken) in Champaign County in three surveys; for each species is given the number of drainages in which it was taken in each survey.

SPECIES	FORBES & RICHARDSON*		THOMPSON & HUNT		LARIMORE & SMITH	
	Per Cent of Stations	Number of Drainages	Per Cent of Stations	Number of Drainages	Per Cent of Stations	Number of Drainages
<i>Lepomis humilis</i>	33.3	4	10.3	3	5.9	3
<i>Minytrema melanops</i>	31.2	4	3.2	2	0.6	1
<i>Ictalurus melas</i>	25.0	4	9.5	5	4.6	5
<i>Labidesthes sicculus</i>	12.5	2	4.0	1	2.0	1
<i>Pomoxis nigromaculatus</i>	14.6	3	2.4	1	1.3	1
<i>Esox americanus</i>	20.8	4	20.6	5	11.2	6
<i>Chaenobryttus gulosus</i>	6.2	1	0.8	1	0.6	1
<i>Hybopsis amblops</i>	12.5	2	6.4	3	0.0	0
<i>Pimephales vigilax</i>	12.5	1	3.2	2	0.0	0
<i>Etheostoma chlorosomum</i>	2.1	1	0.8	1	0.0	0
<i>Notropis boops</i>	2.1	1	1.6	1	0.0	0
<i>Opsopoeodus emiliae</i>	2.1	1	1.6	1	0.0	0
<i>Notropis heterolepis</i>	4.2	2	0.0	0	0.0	0
<i>Ictiobus bubalus</i>	2.1	1	0.0	0	0.0	0
<i>Hybopsis aestivalis</i>	2.1	1	0.0	0	0.0	0

*Includes *Opsopoeodus emiliae* and *Hybopsis aestivalis* recorded by Large (1903:15, 19)

shown by *N. lutrensis*, which entered the county between 1928 and 1959. *Ambloplites rupestris* and *Micropterus dolomieu* show an irrefutable increase in abundance and occurrence within Champaign County, but there is no evidence that their ranges within the state have changed. These species would have been benefited by the increased stream gradient and lower maximum water temperatures that may have resulted, as suggested in the section on Changes in Stream Habitats, from drainage and dredging operations. Similarly, *Hypentelium nigricans*, *N. chrysocephalus*, *Hybopsis biguttata*, *Noturus flavus*, and *Camptostoma anomalum* show decided, if inexplicable, increases in occurrence within the county, but their over-all ranges within the state appeared to be the same in 1959 as 60 years before.

On the basis of evidence from the three surveys, 15 species exhibited an equally striking decrease in abundance and in shrinkage of distributional pattern within the county over the 60-year period of study. These species, the percentage of stations in which they were found, and the number of drainages in which they were taken at each survey are listed in table 8.

Data for the entire period covered by the three surveys indicate that *Ictiobus bubalus*, *Hybopsis aestivalis*, and *Notropis heterolepis* disappeared from Champaign County before 1928. *N. heterolepis*, if Forbes & Richardson correctly identified the specimens to which they assigned this name, is of particular interest because it occurred in two different drainage systems prior to 1899 and probably disappeared with the draining of the once extensive prairie marshes. *I. bubalus* may be expected to be taken again in Champaign County, for it occurs in large streams only a few miles outside the county.

Hybopsis amblopi, *Pimephales vigilax*, *Etheostoma chlorosomum*, *Notropis boops*, and *Opsopoeodus emiliae* may have declined in numbers by 1928; they disappeared between 1929 and 1959. The remaining seven species listed in table 8 are still present, but they are much less common than formerly. All of them except *Esox americanus* suggest that their marked decline in the county occurred between 1899 and 1928. One, *Minytrema mela-*

nops, was described by Large (1903:12) as "abundant in the Wabash basin and in the headwaters of the Kaskaskia" and "apparently prefers the weedy prairie creeks in situations where it is abundant." *E. americanus* was evidently about equally common in 1899 and 1928 but had decreased sharply by 1959, presumably because of the destruction by dredging of its preferred habitat (pools with luxuriant aquatic vegetation).

The extirpation of six other species (*Ictiobus cyprinellus*, *I. niger*, *Notropis amnis*, *Noturus exilis*, *Lepomis punctatus*, and *Etheostoma gracile*) from Champaign County is almost certain; they have not been included in table 8 because information regarding their abundance, or even their presence, was unavailable prior to the 1928 investigation. Of the extirpated species, *E. gracile*, *N. exilis*, and *Hybopsis amblopi* are noteworthy because they were, until 1928, peripheral populations in the county. The northernmost record in the range of *E. gracile*, the easternmost record in the range of *N. exilis*, and the westernmost record of *H. amblopi*, at least in this region, were in Champaign County. Within the past 30 years, shrinkage in the ranges of these three species, respectively to the south, west, and east, has occurred. This shrinkage is evident over the state as a whole as well as within Champaign County.

Despite the impressive changes in abundance and distribution of the species discussed in the paragraphs above, it is difficult to describe the changes in the Champaign County fish fauna as radical, for roughly half of the species showed no decided trends. Examination of distribution maps, figs. 15-70, that accompany this report will reveal that the occurrence of several species was remarkably similar throughout the 60-year period of observation. Several species exhibited considerable changes in distribution but these species cannot be regarded as being any more or less common, or more or less widely distributed, in the county in 1959 than they were in 1928 or 1899. In view of the great changes in land use, in the stream courses, and in the stream habitats that occurred in the county over a 60-year period, and the catastrophic effects of the several drought years since 1930,

Table 9.—The number of species of fish taken and recorded in each of the six Champaign County drainages and the number of species restricted to each of these drainages.

SURVEY	SANGAMON		SALT FORK		MIDDLE FORK		KASKASKIA		LITTLE VERMILION		EMBARRASS	
	Species Recorded in Drainage	Species Restricted to Drainage	Species Recorded in Drainage	Species Restricted to Drainage	Species Recorded in Drainage	Species Restricted to Drainage	Species Recorded in Drainage	Species Restricted to Drainage	Species Recorded in Drainage	Species Restricted to Drainage	Species Recorded in Drainage	Species Restricted to Drainage
Forbes & Richardson.....	40	5	47	9	24	3	18	2	---	---	8	0
Thompson & Hunt.....	50	13	41	7	36	4	14	4	14	0	25	0
Larimore & Smith.....	54	6	51	3	47	4	39	5	18	1	32	0
Total.....	67	7	64	3	55	3	51	4	20	1	36	0

it is indeed astounding that many of our species were still present in the same streams in 1959 and probably in approximately the same numbers then as 30 and 60 years previously.

Results of an analysis of distribution of species by drainage systems are summarized in table 9. It will be seen that Forbes & Richardson found the Salt Fork drainage both the richest in number of species, with 47, and the most distinctive, with 9 species occurring there exclusively. On the basis of these same criteria, they found the Sangamon to be second, the Middle Fork third, the Kaskaskia fourth, and the Embarrass fifth. They made no collections in the Little Vermilion drainage. About 30 years later, Thompson & Hunt found the Sangamon richest in species and most distinctive, with a total of 50 species, 13 of which they did not find elsewhere. Other drainages ranked as follows: Salt Fork, Middle Fork, Kaskaskia, Embarrass, and Little Vermilion. Our findings were similar to those of Thompson & Hunt, except that we found fewer species restricted to a single drainage, and no species restricted to the Embarrass drainage.

The most significant results of this analysis, aside from the richness of the fauna in each drainage, are the number of species restricted to a drainage system. More than 10 per cent of the 67 species

in the Sangamon, almost 9 per cent of the 51 species in the Kaskaskia, almost 6 per cent of the 55 species in the Middle Fork, roughly 5 per cent of the 20 species in the Little Vermilion and of the 64 species in the Salt Fork occurred only in their respective drainages. None of the 36 species in the Embarrass occurred exclusively in that drainage. This lack of species distinctiveness for the Embarrass is clearly evident on the distribution maps.

We can express distributional changes by examining the drainage systems and tallying the number of changes observable when the Thompson & Hunt list of species is compared with that compiled by Forbes & Richardson and the Larimore & Smith list of species is compared with that compiled by Thompson & Hunt. A summary of these changes is presented in table 10.

Table 10 indicates that the greatest number of changes between the Forbes & Richardson and the Thompson & Hunt surveys occurred in the Middle Fork drainage; 30 species were taken in one of these surveys but not the other. The least number of changes occurred in the Embarrass; 21 species were taken in one of these surveys but not the other. No collections were made in the Little Vermilion by Forbes & Richardson. Within the approximately 30 years between the survey of Forbes & Richardson and the survey of

Table 10.—Changes (increases or decreases) between surveys (FR=Forbes & Richardson; TH=Thompson & Hunt; LS=Larimore & Smith) in the number of species of fish in Champaign County drainages. Changes include both the taking of species not previously taken and the failure to retake species previously taken in a drainage. Forbes & Richardson made no collections in the Little Vermilion.

DRAINAGE	FR-TH	TH-LS	TOTAL CHANGES
Kaskaskia	27	20	47
Middle Fork	30	15	45
Sangamon	29	15	44
Salt Fork	22	17	39
Embarrass	21	11	32
Little Vermilion	...	8	8
Total changes	129	86	215

Thompson & Hunt, a total of 129 changes in distribution occurred in the five drainage systems considered here. Between 1928 and 1959, the greatest number of changes occurred in the Kaskaskia; the least number of changes occurred in the Little Vermilion drainage. Within the period between 1928 and 1959, a total of 86 changes occurred in the six drainages of the county. For the over-all period of study, approximately 60 years, the greatest number of changes occurred in the Kaskaskia drainage.

If changes in the occurrence of fish reflect the amount of modification of a stream and its habitats, it should follow that much greater modification occurred during the first 30 years of this century than during the second 30 years. This assumption is substantiated by the historical record of land use and can be observed by noting, in table 10, the interval when the greatest changes in species composition occurred. It should also follow that the most extensive changes in land use early in this century were in the Middle Fork and Sangamon basins and, after 1928, in the Kaskaskia and Salt Fork basins. The small amount of change in the Little Vermilion is probably due to its small size and comparatively small number of habitats; only the extreme headwaters of this drainage are in Champaign County.

ECOLOGICAL ASSOCIATIONS

Ecological associations can be drawn between a species of fish and various en-

vironmental factors comprising its habitat, or between a species of fish and other species of fishes with which it is found. However, a clear separation of the influences of the physical environment from those exerted by fishes is often difficult or impossible.

Species Associated With Various Stream Habitats

The stream habitats defined in table 4 on the basis of water velocity, depth, and area of drainage basin contained fish populations characteristic of each. As shown in the tabulations below, some species taken in the Champaign County surveys were limited in their occurrence to a specific habitat, whereas others were more generally distributed. Our assignment of a particular species to a particular habitat was complicated by seasonal changes in fish distribution, differences in distribution of young and adult fish, and lack of uniformity throughout each habitat.

Species of Rivulets and Small Creeks

- Etheostoma spectabile
- Camptostoma anomalum
- Semotilus atromaculatus
- Fundulus notatus
- Pimephales notatus
- Erimyzon oblongus, young
- Catostomus commersoni, young
- Lepomis cyanellus, young
- Ictalurus natalis, young
- Ictalurus melas, young

Species of Large Creeks

- Riffles: sand and fine gravel
 - Ericymba buccata
 - Etheostoma spectabile
 - Notropis dorsalis
 - Camptostoma anomalum
 - Phenacobius mirabilis
- Riffles: gravel and rubble
 - Etheostoma caeruleum
 - Etheostoma blennioides
 - Etheostoma flabellare
- Pools: shallow, moderate current
 - Notropis chrysocephalus
 - Hybopsis biguttata
 - Semotilus atromaculatus
 - Catostomus commersoni
 - Notropis stramineus
 - Notropis spilopterus

Pimephales notatus
Noturus miurus
Etheostoma nigrum
Cyprinus carpio, young
Moxostoma spp., young
Carpionides spp., young
Hypentelium nigricans, young
Percina maculata
Carpionides cyprinus
Hybognathus nuchalis
Notropis lutrensis

Pools: deep, sluggish

Lepomis megalotis
Micropterus dolomieu
Ambloplites rupestris
Esox americanus
Erimyzon oblongus
Notemigonus crysoleucas
Lepomis humilis
Pimephales promelas
Aphredoderus sayanus
Lepomis macrochirus
Ictalurus natalis
Ictalurus melas
Noturus gyrinus
Notropis umbratilis
Lepomis cyanellus
Fundulus notatus

Species of Small Rivers

Riffles: sand and gravel

Notropis whipplei
Ammocrypta pellucida
Phenacobius mirabilis
Notropis dorsalis

Riffles: boulders and rubble

Hypentelium nigricans
Etheostoma blennioides
Noturus flavus
Notropis rubellus
Etheostoma zonale

Pools: shallow, moderate velocity

Moxostoma erythrurum
Percina phoxocephala
Moxostoma macrolepidotum
Carpionides velifer
Percina caprodes
Hybognathus nuchalis
Lepomis megalotis
Lepomis cyanellus

Pools: deep, sluggish

Micropterus punctulatus
Moxostoma anisurum
Cyprinus carpio
Dorosoma cepedianum
Micropterus salmoides

Pomoxis annularis
Pylodictis olivaris
Lepomis macrochirus
Aplodinotus grunniens
Ictalurus natalis
Ictalurus melas

Species Associated With Various Ecological Factors

From each of our quantitative samples, the number and weight of each species per 100 square yards were recorded on IBM sorting cards along with measurements or appraisals of the following 13 ecological factors of the habitats: (1) average depth, (2) average width, and (3) average water velocity; composition of the bottom materials as percentage of (4) clay, (5) silt, (6) sand, (7) silt and sand, (8) gravel, and (9) rubble; occurrence of (10) aquatic vegetation, (11) debris, and (12) bank vegetation; degree of (13) water turbidity. Each of these ecological factors was assigned numerical values to express the total actual range of field measurements (examples: depth in feet, per cent sand).

For each value of an ecological factor (for example, *over bottom materials that were 30 per cent sand*), we determined:

(1) the total number of individuals of each species associated with the value.

Example: 100 creek chubs taken over 30 per cent sand.

(2) the number of collections in which this species occurred.

Example: Creek chubs occurred in 10 collections.

(3) the total number of collections associated with the ecological value.

Example: Bottom materials composed of 30 per cent sand were found in 20 collections.

(4) the average number of fish of each species found with the value, figured by dividing (1) by (3).

Example:

$$\frac{100 \text{ creek chubs over } 30\% \text{ sand}}{20 \text{ collections over } 30\% \text{ sand}} =$$

5 chubs per collection over 30% sand

(5) the per cent of collections associated with the ecological value that contained the species, figured by dividing (2) by (3).

Example:

$$\frac{10 \text{ collections of chubs}}{20 \text{ collections over } 30\% \text{ sand}} =$$

50 per cent of collections over this bottom contained chubs

Thus, in the examples above, five creek chubs were taken per collection over 30 per cent sand bottom material, and creek chubs were present in 50 per cent of such collections.

Ecological associations were determined for collections from each drainage system and then for the entire county.

The association figures revealed (1) ecological factors that comprised the general habitat of each species (used in assigning species to stream habitats in the preceding section); (2) inconsistencies that appeared when a species was related to a specific ecological factor in one stream system and not in another; and (3) the absence of any single factor that determined the distribution or abundance of most species.

Such ecological associations may be of definite value in defining the general habitat of a species but are quite misleading in determining its environmental requirements, for the influences of each environmental factor in a natural habitat cannot be separately evaluated. We cannot be sure just which factor or factors in a habitat have a controlling influence on a species. For example, gizzard shad showed a high degree of association with deep, quiet pools. However, they may have been responding not to depth or to low water velocity but to the soft sands and silts usually found in such pools. Too, a species might have been closely associated with a specific factor that did not comprise a noticeable part of the habitat.

A few species were closely restricted to rather specialized habitats. The restrictions, while quite obvious during field collecting, were not always shown by our calculations. Some of the most notable examples were *Ammocrypta pellucida*, which occurred only in clear water flowing over clean sand; *Esox americanus*, which reached its greatest abundance in quiet, silt-bottomed pools choked with vegetation; *Noturus flavus*, which seemed

to prefer deep riffles or shallow pools with moderate current and scattered rubble and flat rocks; and *Aphredoderus sayanus*, which was invariably in mud-bottomed pools of streams with little current. However, in general, most fishes showed a remarkable plasticity in their environmental tolerance.

Species Associated With Other Species

Associations between species can be determined (1) through examining which species are mutually associated with a set of ecological factors and (2) through examining the mutual occurrence and abundance of two or more species. The degree of association between pairs of several kinds of common Champaign County fishes was determined by calculating the coefficient of correlation (r) between their numbers in 100 square yards of stream. Coefficients were determined for the collections from each drainage system, as well as for the entire county. Several definite and sometimes surprising associations were evident.

***Notropis dorsalis*—*Ericymba buccata*.**—Champaign County is on the edge of the range of each of these species, *Notropis dorsalis* becoming more abundant westward and *Ericymba buccata* becoming more abundant eastward. Because of the east-west separation in distribution, these two species usually do not occur abundantly in the same drainage system. They have been considered ecological equivalents, and competition between the two has been implied. Trautman (1957:376) noted the shrinking in size of the Ohio range of *N. dorsalis* and the invasion and great increase in numbers of *E. buccata* in a territory formerly occupied by *dorsalis*. However, in our Sangamon River collections, where both species were abundant, they occurred together in a highly significant degree (P less than 0.01) of association, table 11. This situation indicates their preference for similar habitats and disputes the idea that there is strong competition between the two. *N. dorsalis*, although occurring in two other Champaign County drainages (Kaskaskia and Middle Fork), was abundant only in the Sangamon, so that further comparisons could not be made.

Table 11.—Degree of association between four species of fish in the Sangamon drainage. Correlation coefficient (r) of 0.438 is significant at the 0.02 level.

SPECIES	<i>Notropis chrysocephalus</i>	<i>Notropis dorsalis</i>	<i>Ericymba buccata</i>
<i>Erimyzon oblongus</i>	0.668	0.587	0.187
<i>Notropis chrysocephalus</i>	-----	0.874	0.464
<i>Notropis dorsalis</i>	-----	-----	0.771

Table 12.—Degree of association between four species of fish in the Middle Fork drainage. Correlation coefficient (r) of 0.934 is significant at the 0.02 level.

SPECIES	<i>Erimyzon oblongus</i>	<i>Notropis chrysocephalus</i>	<i>Phenacobius mirabilis</i>
<i>Catostomus commersoni</i>	0.977	0.965	0.978
<i>Erimyzon oblongus</i>	-----	0.958	0.935
<i>Notropis chrysocephalus</i>	-----	-----	0.973

Notropis chrysocephalus—*Erimyzon oblongus*.—These species formed one of the least expected associations observed among Champaign County fishes, occurring in a significant (P 0.02 or less) association in three of five drainage systems, fig. 12. In the Sangamon drainage they were closely associated with the two species previously discussed, table 11. In the Middle Fork drainage, however, they formed a strong association with *Phenacobius mirabilis* and *Catostomus commersoni*, table 12.

Catostomus commersoni—*Phenacobius mirabilis*.—These two species occurred in significant associations (P 0.02 or less) in three of the five Champaign County drainages considered, as well as in the county-wide analysis. They

were significantly associated with *Erimyzon oblongus* and *Notropis chrysocephalus* in the Middle Fork drainage, table 12. Both species were closely associated with *Hybopsis biguttata* in the Salt Fork drainage, fig. 12.

Miscellaneous Associations.—Several species showed different associations in different stream systems; for example, *Notropis umbratilis* was significantly (P 0.02 or less) associated with such species as *Hypentelium nigricans*, *Notemigonus crysoleucas*, *Notropis chrysocephalus*, *Phenacobius mirabilis*, and *Erimyzon oblongus*, each association in a different stream. This lack of similarity or consistency in associations seems to suggest little interdependence between species but rather dependence of certain

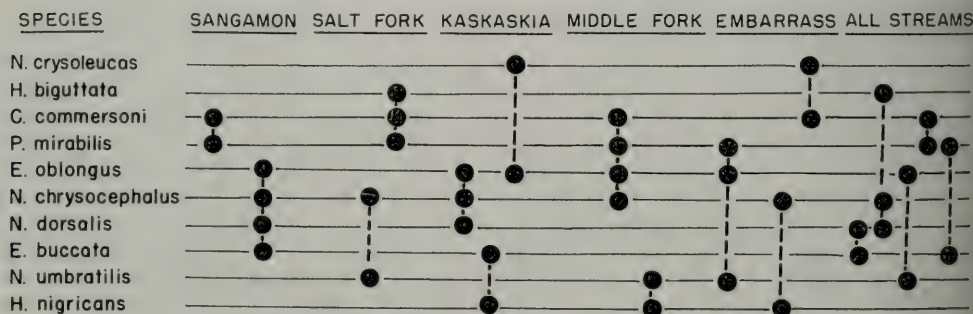


Fig. 12.—Significant associations of several fishes in five drainages of Champaign County. The coefficient of correlation (r) was better than the 0.02 level of significance except in the column "All Streams," where the associations between *Notropis dorsalis* and *Ericymba buccata* and between *N. dorsalis* and *Hybopsis biguttata* were significant only to the 0.03 level.

species on certain ecological factors. These factors may occur together in one stream system, thus bringing two species together, or they may be separated in another stream system, thus separating species. Two species might occur together temporarily or abnormally, as during periods of low water when many species may be forced into constricted water areas.

Thompson & Hunt (1930:66) stated, "Most instances of the association of different species of fishes are explained satisfactorily by similar environmental preferences." However, they pointed out a very significant exception to this statement in their discovery of a close association between *Hybopsis biguttata* and *Notropis chrysocephalus*. For these two species, they suggested a direct dependence, at least at some stage in the life cycle. Our 1959 collections revealed a significant (P less than 0.01) association between these two minnows when all the collections for the county were considered together, but no consistency of association in any of the separate drainage systems, even though both species were taken in rather great numbers in four of the systems.

GENERAL ABUNDANCE AND OCCURRENCE

The use of collecting methods in 1959 that differed from those of 1928 contributed to the difficulty of comparing the two

surveys with respect to the general abundance and occurrence of fishes as recorded.

Some of the variables in such comparisons were eliminated by consistently following throughout each survey a procedure adapted to it and by excluding from consideration any stations that in either survey were influenced strongly by pollution or that were not visited by both survey parties. Seventy-one collections were then available for comparison.

Average Number of Species Per Station

A consistently larger number of species per station was found in collections taken in the 1959 than in the 1928 survey. The average was 13.2 species per station in 1928 and 19.0 in 1959; the ratio was 1:1.4, table 13. The samples taken in the later survey were considerably larger numerically and thus might be expected to contain a higher percentage of those species present at the collecting stations. In the two surveys, the drainages were in the same order with respect to average number of species per station; for example, in each survey, the Middle Fork had the largest number of species per station and the Embarrass the smallest number.

In the 1959 survey, quantitative collections from the blocked-off stations produced between 88 and 97 per cent of the total number of species collected at

Table 13.—Average number of species per station and average number of fish per 100 square yards taken in 1928 and 1959 at 71 stations (not noticeably affected by pollution) in five major drainages of Champaign County (no quantitative samples were taken from the Little Vermilion); also, average number of pounds of fish per 100 square yards in 1959.

DRAINAGE SYSTEM	NUMBER OF STATIONS	AVERAGE NUMBER OF SPECIES PER STATION				AVERAGE NUMBER OF FISH PER 100 SQUARE YARDS			AVERAGE NUMBER OF POUNDS OF FISH PER 100 SQUARE YARDS IN 1959
		1928	1959		Ratio 1928:1959	1928	1959	Ratio 1928:1959	
		Total Collection	Quantitative Sample	Total Collection					
Middle Fork	5	20.6	30.4	31.4	1:1.5	553	286	1:0.5	5.10
Sangamon	28	17.3	20.1	21.9	1:1.3	468	562	1:1.2	2.89
Salt Fork	18	9.1	14.4	15.3	1:1.7	429	470	1:1.1	2.80
Embarrass	9	6.8	12.6	14.3	1:2.1	185	571	1:3.1	1.74
Kaskaskia	11	11.2	13.7	15.5	1:1.4	202	150	1:0.7	0.90
All systems	71	13.2	17.4	19.0	1:1.4	387	457	1:1.2	2.57

any site; in other words, we added approximately 10 per cent more species by "cruising" with a seine in adjacent habitats. With the small amount of effort expended, "cruising" furnished desirable additions to the collections.

Average Number of Fish Per 100 Square Yards

Although the average numbers of fish per 100 square yards collected in both surveys varied greatly from stream to stream, table 13, the county averages for the two surveys did not differ greatly; the ratio of the 1928 to the 1959 average was 1:1.2. The most striking difference between the two surveys was that the Middle Fork produced the greatest number of fish per 100 square yards in 1928 and next to the lowest number in 1959, whereas the Embarrass yielded the lowest number in 1928 and the highest number in 1959. There was no apparent habitat change that might account for this difference. A difference of the same kind was not evident in the number of species taken or in the weight of fish collected in the two surveys of these streams. The highest ratio of increase from 1928 to 1959 in the number of species as well as in the number of fish collected per 100 square yards occurred in the Embarrass, although in the 1959 survey the number of species and the pounds collected in the stream were low, table 13.

Average Weight of Fish Per 100 Square Yards

The weights of Champaign County fish taken in 1959 could not be compared with those taken in 1928 because there were no exact weight data from the Thompson & Hunt survey. Thompson & Hunt (1930:39) estimated that they took 150 pounds of fish per acre in the 1928 collections. In the 1959 survey, the number of pounds per 100 square yards varied from 0.9 in the Kaskaskia to 5.1 in the Middle Fork and averaged 2.6 for the entire county. This county average is equivalent to 124.4 pounds per acre.

The poundage figures from the 1959 survey should not be regarded as representing the total population present in any of the areas fished. Using the electrofishing equipment employed in the 1959

survey of Champaign County to fish Jordan Creek, a small stream in adjoining Vermilion County, Larimore (1961:3-5) took an average of 54 per cent of the weight and 51 per cent of the number of the fish population present in the areas fished. The Jordan Creek population taken by electrofishing and other means amounted to nearly 25,000 fish weighing 163.9 pounds per acre. If the same rate of electrofishing success applied to our Champaign County collections, the total populations would have been close to an average of 250 pounds per acre for the stations worked in 1959.

DISTRIBUTION AND STREAM SIZE

Thompson & Hunt, using their 1928 Champaign County collections, explored both the composition and the size of fish populations in relation to stream size, expressed as square miles of drainage basin at point of collection. They related stream sizes to the numbers and weights of fish, to the average sizes of fish taken, to the number of species, and to the distribution of various species. They grouped their collections into 10 classes according to stream size at the collecting stations, beginning with stations having 0.5-1.0 square mile of drainage and doubling the stream sizes up to the class of 256.0-512.0 square miles.

Relationships With Stream Size

We have analyzed quantitative data from the 1959 survey in a manner similar to that used by Thompson & Hunt in order to determine whether the 1959 collections support the conclusions of Thompson & Hunt (1930:41-6), given in italics following paragraph headings below. Including only those stations receiving no noticeable pollution and those visited in both 1928 and 1959, table 14, we plotted our data for 1959 in fig. 13 to correspond roughly to the treatment shown by Thompson & Hunt in their fig. 6; that is, we combined the data for our two smallest classes of stream size and for our three largest classes of stream size. Thompson & Hunt combined the data for their three smallest and their three largest classes of stream sizes. We made no quantitative collections from the two smallest

Table 14.—Average number of species per station and average number and weight of fish taken per 100 square yards in 1928 and 1959 at 71 stations (not noticeably affected by pollution) classified by size of drainage basin; also, average number of pounds of fish per 100 square yards in 1959.

STREAM SIZE (SQUARE MILES OF DRAIN- AGE)*	NUMBER OF STATIONS	AVERAGE NUMBER OF SPECIES PER STATION				AVERAGE NUMBER OF FISH PER 100 SQUARE YARDS			AVERAGE NUMBER OF POUNDS OF FISH PER 100 SQUARE YARDS IN 1959
		1928 Total Collection	1959		Ratio 1928: 1959	1928	1959	RATIO 1928: 1959	
			Quantita- tative Sample	Total Collection					
2-4 ---	2	3.0	7.5	8.5	1: 2.8	126	1700	1: 13.4	2.9
4-8 ---	4	10.2	10.5	11.5	1: 1.1	676	617	1: 0.9	2.8
8-16 ---	13	9.5	12.2	13.5	1: 1.4	462	718	1: 1.6	2.2
16-32 ---	10	13.3	15.6	16.2	1: 1.2	539	704	1: 1.3	2.1
32-64 ---	17	14.2	15.9	17.9	1: 1.3	397	367	1: 0.9	2.7
64-128 ---	5	14.0	21.0	21.8	1: 1.6	345	440	1: 1.3	3.7
128-256 ---	10	20.0	26.1	28.3	1: 1.4	309	97	1: 0.3	3.7
256-512 ---	10	11.9	22.8	24.9	1: 2.1	157	80	1: 0.5	1.5

*Classification used by Thompson & Hunt (1930). In our work, we considered the numerals as designating size limits, so that a stream classified as size 4-8 had a drainage area of more than 4 and not more than 8 square miles.

units of stream size treated by Thompson & Hunt; hence, our first point represents stations having 2-8 square miles of drainage, not 0.5-4 miles as in the treatment by Thompson & Hunt.

Number of Species and Stream Size.—*The number of species of fishes per collection increases downstream.* This hypothesis of Thompson & Hunt was supported by our collections in 1959. Our

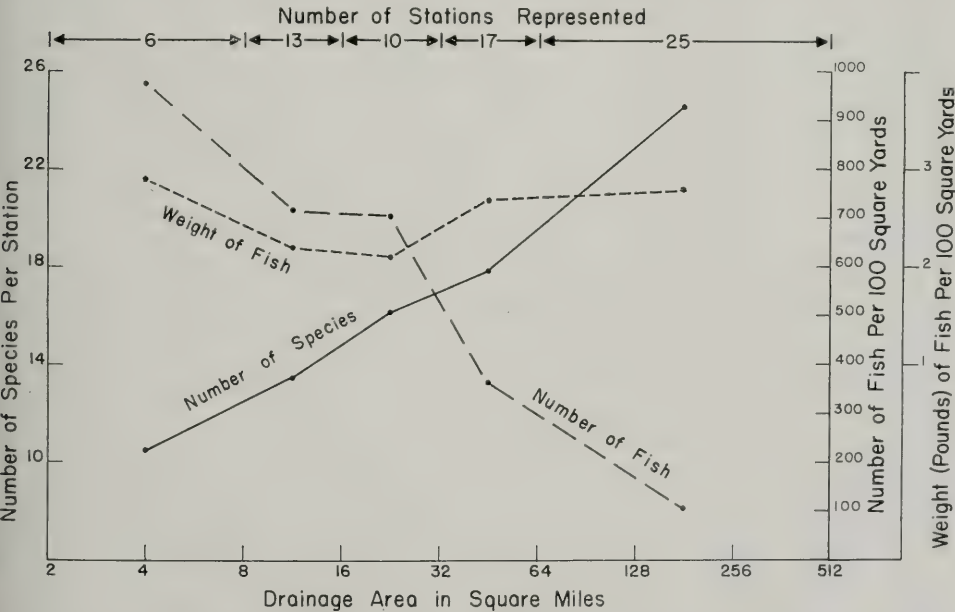


Fig. 13.—Relationships of weight, number of individuals, and number of species to size of the drainage area. Data for collections from the two smallest and the three largest areas of stream size, table 14, were combined, as explained in the text under Relationships With Stream Size on page 340.

Table 15.—Correlation between size of drainage area (square miles) and the number of species per collection and the number and weight of fish taken per 100 square yards at 70* stations in 1959.

DRAINAGE SYSTEM	NUMBER OF COLLECTIONS	COEFFICIENT OF CORRELATION (r) WITH SQUARE MILES OF DRAINAGE		
		Number of Species per Collection	Number of Fish per 100 Square Yards	Pounds of Fish per 100 Square Yards
Middle Fork.....	5	0.76	-0.94	0.19
Sangamon.....	28	0.66	-0.34	-0.18
Salt Fork.....	17	0.73	-0.62	-0.16
Embarrass.....	9	0.64	-0.46	-0.36
Kaskaskia.....	11	0.58	0.18	0.11
All systems.....	70	0.64	-0.30	0.00

*One station, of the 71 used in related analyses, was omitted from the calculations in this table.

collections from all of the drainage systems in the county showed an increase in the number of species in a downstream direction. When all of our collections for the county were combined, table 14 and fig. 13, we found a significant positive relationship ($r = 0.64$, table 15) between number of species and downstream direction. The average numbers of species taken in the areas farthest downstream in both 1928 and 1959 were slightly below the projected average numbers, possibly because the sampling methods were not so well adapted to the largest water areas as to the smaller areas upstream.

An increase in the number of species in a downstream direction probably resulted from the greater variety of habitats associated with increasing stream size: many stations in large streams included units of small stream habitats. Thompson & Hunt pointed out that only unspecialized species can live under the widely varying conditions of the small streams.

Number of Fish and Stream Size.—*The actual number of fishes per unit area decreases downstream.* Most of our collections supported this hypothesis of Thompson & Hunt. Among our collections, only those from the Kaskaskia showed no definite inverse relationship between numbers of fish and stream size, table 15. Our collections from all of the streams in the county averaged together revealed a definite decrease in the number of individuals per unit area downstream, fig. 13 and table 15.

Fish Weight and Stream Size.—*With this decrease of number of fishes downstream there is a corresponding increase in the average size of the individuals, so that, other factors being equal, the total amount of fish flesh per unit area is probably almost constant.* The average size of the fish we collected fluctuated greatly from station to station, even in streams of similar size; however, the average size of individual fish increased generally in the downstream direction. The downstream increase in average size of individuals was influenced by the occurrence of a greater number of large adults of large species (the suckers, catfishes, basses) than was found upstream.

In our collections, the weight of fish flesh per unit area, as well as the average size of fish, fluctuated greatly from station to station, even in streams of similar size. The correlation between fish weight and stream size was low in each stream and for the county as a whole, table 15. However, the average numbers of pounds of fish per 100 square yards were similar enough in streams of different sizes, table 14, that when plotted, fig. 13, they lend some support to the idea that total weight of fish flesh per unit area is similar in streams of different sizes.

Frequency Distribution and Stream Size.—*Fishes . . . exhibit frequencies which vary with stream size in a very consistent and definite manner for each species.* The frequency distribution of our fishes in relation to stream size is

shown in tables 16-23. Distribution patterns were different for each species; some species showed definite patterns of distribution based on stream sizes, whereas

others occurred seemingly with no relation to stream sizes.

As might be expected in a group of streams that differed from each other in

Table 16.—Suckers. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Erimyzon oblongus</i>	105.6	4.6	12.6	2.9	5.2	5.3	0.3	0.3
<i>Catostomus commersoni</i>	6.2	8.0	2.9	1.7	2.9	3.4	1.7	0.8
<i>Hypentelium nigricans</i>	---	0.2	0.1	1.2	1.0	1.9	1.5	0.6
<i>Moxostoma macrolepidotum</i> *.....	---	---	---	---	---	---	0.2	0.2
<i>Moxostoma anisurum</i> †.....	---	---	---	---	tr.	---	---	tr.
<i>Moxostoma erythrurum</i> ‡.....	---	---	---	0.2	tr.	---	2.4	1.6
<i>Carpiodes cyprinus</i> ‡.....	---	---	---	0.1	1.4	11.2	0.4	0.1
<i>Carpiodes velifer</i> §.....	---	---	---	---	---	---	1.0	tr.

*Sangamon only.

†Sangamon and Salt Fork only.

‡Sangamon, Salt Fork, and Middle Fork only.

§Middle Fork only.

Table 17.—Mud-eating minnows. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Pimephales notatus</i>	445.9	126.6	91.6	168.4	68.7	55.1	15.2	10.1
<i>Camptostoma anomalum</i>	566.7	109.6	99.2	66.0	25.5	38.7	7.9	5.2
<i>Pimephales promelas</i> *.....	---	---	11.3	2.0	0.6	0.2	tr.	0.1
<i>Hybognathus nuchalis</i> †.....	---	---	0.2	---	0.1	33.6	---	---

*Kaskaskia and Sangamon only.

†Kaskaskia only.

Table 18.—Minnows of the genus *Notropis*. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Notropis spilopterus</i>	---	0.2	0.2	0.6	0.5	4.1	5.0	13.4
<i>Notropis stramineus</i>	---	0.2	32.3	12.5	16.9	33.2	5.1	9.5
<i>Notropis umbratilis</i>	57.8	0.2	1.6	2.2	4.7	1.5	1.8	2.4
<i>Notropis chrysocephalus</i>	---	15.2	78.0	158.7	53.2	18.1	6.1	12.1
<i>Notropis dorsalis</i> *.....	---	---	109.0	112.1	36.2	7.1	0.6	1.5
<i>Notropis lutrensis</i> †.....	---	---	14.9	0.4	1.0	4.6	---	---
<i>Notropis whipplei</i> ‡.....	---	---	0.1	0.4	---	0.5	0.6	1.6
<i>Notropis rubellus</i> §.....	---	---	---	---	---	---	1.4	---

*Sangamon, Middle Fork, and Kaskaskia only.

†Kaskaskia and Sangamon only.

‡Sangamon, Embarrass, and Middle Fork only.

§Middle Fork only.

habitat succession and in degree of human-induced modification, most fish species showing definite patterns of distribution based on stream size did not exhibit these patterns in all the Champaign Coun-

ty streams in which they were present. However, some support for the Thompson & Hunt concept expressed above was found. The following species showed somewhat consistent distribution patterns

Table 19.—Other minnows and the carp. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Semotilus atromaculatus</i>	250.0	263.8	130.9	55.2	56.1	31.3	4.3	8.1
<i>Phenacobius mirabilis</i>	0.6	1.1	5.2	1.3	1.0	1.5	0.4	0.1
<i>Ericymba buccata</i>	---	11.1	67.2	8.9	38.0	29.3	1.5	0.4
<i>Hybopsis biguttata</i> *	20.8	0.5	52.0	23.3	6.5	9.0	0.7	1.4
<i>Notemigonus crysoleucas</i>	---	---	0.2	tr.	0.3	0.8	1.3	0.5
<i>Cyprinus carpio</i>	---	---	3.5	0.2	4.3	3.8	1.0	0.3

*All streams except Embarrass.

Table 20.—Catfishes. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Ictalurus natalis</i>	4.3	---	0.4	0.9	0.5	0.2	0.1	0.1
<i>Noturus gyrinus</i> *	---	---	0.1	0.3	tr.	0.2	tr.	0.1
<i>Noturus flavus</i> †	---	---	---	0.1	0.1	0.1	0.6	0.2
<i>Noturus miurus</i> ‡	---	---	---	---	0.1	---	1.2	---
<i>Ictalurus punctatus</i> †	---	---	---	---	---	---	0.3	0.3
<i>Pylodictus olivaris</i> §	---	---	---	---	---	---	0.1	---

*Salt Fork, Sangamon, and Kaskaskia only.

‡Middle Fork and Embarrass only.

†Salt Fork, Middle Fork, and Sangamon only.

§Middle Fork only.

Table 21.—Sunfish and bass. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Lepomis megalotis</i>	---	1.5	0.3	0.2	0.7	0.6	0.8	0.2
<i>Micropterus dolomieu</i> *	---	3.2	0.8	1.2	1.3	0.3	1.3	0.2
<i>Micropterus punctulatus</i> †	---	8.2	---	---	---	---	7.0	---
<i>Lepomis macrochirus</i> ‡	---	---	tr.	0.1	---	0.2	0.1	tr.
<i>Lepomis cyanellus</i>	5.0	---	0.2	0.6	1.2	2.8	2.0	1.3
<i>Ambloplites rupestris</i> *	---	---	---	0.4	---	---	0.6	0.3
<i>Micropterus salmoides</i> §	---	---	---	---	---	---	0.1	0.2
<i>Pomoxis annularis</i> *	---	---	---	---	---	---	0.1	tr.
<i>Lepomis humilis</i> †	---	---	---	---	---	---	0.9	---

*Salt Fork, Middle Fork, and Sangamon only.

†Middle Fork only.

‡Salt Fork, Kaskaskia, and Sangamon only.

§Salt Fork and Sangamon only.

in relation to stream size in at least three of five drainage systems in the county:

Catostomus commersoni
Erimyzon oblongus
Hypentelium nigricans
Cyprinus carpio
Ericymba buccata
Ictalurus natalis
Lepomis cyanellus
Etheostoma spectabile

Because of great variation in habitat succession among Champaign County streams, we might suppose that the species showing some consistency in distribution pattern in relation to stream size were those adapted to a wide variety of habitat conditions or to a set of conditions closely related to stream size. The following species apparently were not adapted to these conditions, for their distribution patterns showed no consistency from stream to

stream and little correlation with stream or drainage size:

Notropis chrysocephalus
Notropis stramineus
Notropis umbratilis
Noturus gyrinus
Lepomis megalotis
Etheostoma blennioides
Etheostoma nigrum
Percina maculata

Thompson & Hunt suggested that the place of greatest abundance of a species might be related to a specific stream size. In 1959, each species listed below was taken in greatest abundance in a specific stream size in each drainage:

Moxostoma erythrurum
Camptostoma anomalum
Hybopsis biguttata
Notropis spilopterus
Semotilus atromaculatus

Table 22.—Darters. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Etheostoma nigrum</i>	1.2	23.7	3.9	26.9	6.5	10.4	3.9	2.5
<i>Etheostoma spectabile</i>	38.0	6.3	9.3	44.9	8.9	0.2	0.4	0.2
<i>Percina maculata</i>	---	4.1	0.1	0.5	0.7	0.4	0.8	0.4
<i>Etheostoma flabellare</i> *	---	3.6	0.5	3.6	0.5	---	tr.	0.1
<i>Etheostoma caeruleum</i> †	---	0.4	0.4	---	0.2	---	0.1	---
<i>Etheostoma blennioides</i> ‡	---	0.8	---	---	0.2	0.1	0.9	0.1
<i>Percina caprodes</i> §	---	---	---	0.1	0.1	---	---	0.1
<i>Percina phoxocephala</i> ¶	---	---	---	---	tr.	---	0.7	0.3
<i>Etheostoma zonale</i>|| .....	---	---	---	---	---	---	tr.	0.2

*Salt Fork, Middle Fork, and Sangamon only.

†All streams except Sangamon.

‡Salt Fork, Middle Fork, and Embarrass only.

§Kaskaskia, Sangamon, and Embarrass only.

¶Sangamon and Middle Fork only.

||Sangamon only.

Table 23.—Miscellaneous fishes. Average numbers of each of several species taken in the 1959 survey (quantitative samples only) in streams of various size ranges. Each species average is for only those stream systems in which the species occurred in the quantitative collections.

SPECIES	DRAINAGE AREA OF STREAM IN SQUARE MILES AT POINT OF COLLECTION							
	2	4	8	16	32	64	128	256—512
<i>Fundulus notatus</i> *	---	---	21.4	4.9	0.9	0.8	0.1	0.1
<i>Aphredoderus sayanus</i> †	---	---	0.5	tr.	tr.	0.2	---	tr.
<i>Esox americanus</i> ‡	---	---	0.2	---	0.2	0.5	0.2	---
<i>Dorosoma cepedianum</i> §	---	---	---	---	0.3	---	0.3	2.0
<i>Labidesthes sicculus</i> ¶	---	---	---	---	---	---	---	tr.

*All streams except Middle Fork.

†Sangamon, Embarrass, and Kaskaskia only.

‡Embarrass, Kaskaskia, and Middle Fork only.

§Sangamon only.

¶Salt Fork only.

Other hypotheses by Thompson & Hunt suggest that in certain species the entire population is confined to a certain stream size of very narrow limits. In the 1959 collections, none of the species (among those taken in sufficient numbers to support such a conclusion) was confined to a certain stream size in more than two or three of the five county drainages considered here. This lack of restricted distribution was due probably to the lack of restricted habitats; in streams of the sizes found in Champaign County, some habitats that are characteristic of large streams were found upstream and many habitats that are characteristic of small streams were found downstream. Even ecological factors most closely related to stream size, such as bottom materials and vegetation, were not restricted to a degree that was known to limit the distribution of any species.

In both 1928 and 1959, young and adults of most species occurred abundantly in the same areas. However, the young of some of the suckers had their greatest frequency of occurrence upstream. The following species (in addition to most of the suckers, with their well-known upstream movements to spawn in spring) showed proportionately greater numbers of small fish than large in the upstream areas:

Campostoma anomalum
Cyprinus carpio
Hybognathus nuchalis
Ictalurus natalis
Ambloplites rupestris
Lepomis macrochirus
Micropterus dolomieu
Micropterus punctulatus

Conclusions on Relationships

Information from the 1959 collections reinforced the hypotheses of Thompson & Hunt regarding the distribution of number of species and number of individuals per unit area in relation to stream size, and it agreed moderately well with their theories regarding average size of fish and distribution of weight per unit area. Some of the other suggested relationships between the fishes and stream size appear less tenable, probably because of the great variation in habitat currently found in Champaign County streams. These relationships generally follow the ecological

succession of streams as illustrated by Shelford (1911) in his collections of fishes from creeks in the Chicago region. Shelford's work and the studies of Champaign County fishes are based on the assumption that similar fish communities occupy similar physiographic stages in aging (base leveling) of a stream. Thompson & Hunt contributed several clear, practical expressions and interpretations of stream succession, and their use of drainage area as an expression of stream size can be considered a substantial contribution. The 1959 survey adds further to the knowledge of succession in warm-water streams. It provides data to substantiate many parts of the concept of succession, but at the same time offers an explanation for the many examples of failure of fish distribution to fit the theoretical sequence of stream succession. The major reason for this failure is that base leveling does not often produce a perfect geologic succession and a uniform progression of ecological factors.

DISTRIBUTION AND POLLUTION

Types of pollution have changed considerably during the years spanned by the three surveys of Champaign County fishes. Organic pollution, which began even before the period of the backyard privy, has existed to the present time with its modern scientific treatment of domestic wastes. Sources of chemical pollution have appeared; some of these have disappeared while others continue to threaten aquatic life. Pollution becomes most severe in areas of dense population and industrial development; thus, in Champaign County, it is most severe in the region of Champaign-Urbana, which serves as the focus of the present study. (The State of Illinois Sanitary Water Board in 1951 defined pollution to include alteration of the physical, chemical, and biological properties of any waters to render them harmful to fish or other aquatic organisms. This definition, which would include the effects of temperature change, sediments, and abnormal chemical levels in effluents, will be followed here.)

At the time Forbes & Richardson made their collections in the West Branch, around 1899, untreated organic wastes

from Champaign and Urbana were carried by two gravity-flow sewers that discharged directly into the lower Boneyard creek and into the nearby West Branch proper. There was some additional pollution from stables, the power plant, and a few small industries, but the collections of Forbes & Richardson indicate that the fish population in the West Branch had not been seriously affected, as a variety of species, similar to that which might be found in nearby streams unaffected by pollution, was present, table 24.

A vivid description of conditions in the Boneyard and the West Branch of the Salt Fork for about two decades following the work of Forbes & Richardson was given by Baker (1922:170-85). By

1918, the Boneyard was apparently barren of clean-water organisms. The West Branch from Urbana to St. Joseph was laden with masses of decomposing matter made up of foul-water algae and protozoa, and its bottom was inhabited by slime worms. Even below the junction of the West Branch and the East Branch, conditions were septic, and clean-water life did not appear for a distance of several miles downstream.

In 1917, legislation permitted the organization of the Urbana-Champaign Sanitary District with the result that, by 1924, the sewage from both cities passed through a disposal plant. Although the disposal plant served to improve conditions in the West Branch, a high level of pol-

Table 24.—Numbers of collections in which each of 22 species was taken in three sections of the West Branch and below by Forbes & Richardson (FR), Thompson & Hunt (TH), and Larimore & Smith (LS). No species not taken by Larimore & Smith is included. Figures in parentheses below FR, TH, and LS indicate numbers of collections made, except that they do not include collections made by Thompson & Hunt or Larimore & Smith subsequent to their initial visits. Species taken in the subsequent visits and at no other time are indicated by +.

SPECIES	IN THE 4 MILES ABOVE SEWAGE DISPOSAL PLANT			IN THE 9 MILES BELOW SEWAGE DISPOSAL PLANT			IN THE 4 MILES BELOW JUNCTION OF WEST AND EAST BRANCHES		
	FR (3)	TH (4)	LS (4)	FR (4)	TH (4)	LS (4)	FR (3)	TH (2)	LS (2)
Creek chub.....	0	4	4	1	2	2	3	2	2
Green sunfish.....	2	4	3	4	+	1	0	0	2
Carp.....	0	0	3	0	0	1	0	0	2
Golden shiner.....	2	4	2	3	2	+	1	2	2
Bluntnose minnow.....	3	3	3	3	2	+	2	2	2
Redfin shiner.....	0	3	3	0	3	+	0	1	1
Common shiner.....	0	0	3	2	0	+	0	0	2
Sand shiner*.....	0	0	2	4	0	+	0	1	0
White sucker.....	1	2	2	2	0	+	1	1	1
Stoneroller.....	1	3	3	2	0	+	0	1	0
Silverjaw minnow.....	2	3	2	1	1	+	0	2	0
Creek chubsucker.....	3	2	3	3	0	0	0	1	1
Spotfin shiner*.....	3	0	+	3	1	+	0	1	2
Yellow bullhead.....	1	1	1	0	0	0	0	0	1
Johnny darter.....	1	3	2	3	0	0	3	1	0
Longear sunfish.....	2	2	1	4	0	+	1	1	0
Grass pickerel.....	1	2	0	2	0	0	1	0	1
Golden redbhorse.....	1	0	0	2	0	0	0	0	1
Quillback.....	0	0	0	1	0	0	0	0	1
Bluegill.....	1	1	0	0	0	+	0	0	0
Black crappie.....	1	0	0	1	0	+	1	0	0
Hornyhead chub.....	0	0	+	1	0	0	0	0	0
Number of species taken in first collections.....	23	20	15	33	6	3	20	19	14
Number of species taken in subsequent collections.....	---	---	2	---	1	12	---	---	---

*Presumed to represent only this species at these stations, although name used in early surveys was known to be a composite of two or more species.

lution still existed, and very few fishes were found there by Thompson & Hunt when they made their collections in 1928. Improvements in the efficiency of the sanitary system were made at frequent intervals between 1928 and 1959, and at present most of the Champaign and Urbana wastes are given complete treatment. In recent years, Rantoul, Gibson City, and the Chanute Air Force Base have installed sewage treatment plants.

Although, in the past 60 years, Champaign County has lost such sources of pollutants as the early gas plants and stables, and has improved the sewer systems and the treatment of human waste, it still has to contend with domestic sewage from outlets illegally connected to storm sewers; chemicals that pass unchanged through the treatment plant; oils that wash from roads and machinery; wastes from canning plants, milk plants, and soybean mills; modified water temperatures; and agricultural chemicals, such as modern herbicides and insecticides. It has the University of Illinois chemical laboratories, the Chanute Air Force Base machinery, and an ever-increasing number of industries.

Along with these pollutants, there is the growing problem of an increasing volume of effluents, which may be detrimental to aquatic life, no matter how well they have been treated. The Champaign-Urbana community and the West Branch provide a good example. In October, 1917, a total flow of 3,000,000 gallons per day was reported for the Salt Fork below the disposal plant (Baker 1922:171). About half of this volume (1,500,000 gallons per day) was from the sanitary treatment plant. The natural stream flow was low when the measurement was made and is comparable to that during the low water period of September, 1959, when we studied the West Branch.

In September, 1959, the total volume of sewage going through the plant was 7,276,000 gallons per day, nearly five times the volume cited by Baker for 1917. (This and similar 1959 figures are from a monthly report of the Urbana-Champaign Sanitary District.) If the natural volume of the flow in the West Branch has not changed over these years, and the sewage effluent has increased nearly five-fold, the

West Branch below the disposal plant must be nearly three times as large as it was in 1917. The total flow has changed from one-half effluent in 1917 to four-fifths effluent in 1959. In September, 1959, this effluent had a biochemical oxygen demand of 9 p.p.m., which would quickly reduce the oxygen in the natural stream water with which it was mixed; natural agitation of the flowing waters would, of course, partially replace the dissolved oxygen used up by the effluent material. In spite of the present high level of efficiency for the treatment plant, which produces an effluent that is as nearly perfect as sanitary engineers consider practical, the stream remains unfit for most aquatic life. The problem centers on the great volume of effluent that is produced and on the accumulation of chemical agents that preclude existence of clean-water organisms.

Areas of Chronic Pollution

Seven principal areas of chronic pollution, fig. 14, affect the distribution of Champaign County fishes, figs. 15-70.

The Boneyard.—Because of its location in the center of Champaign-Urbana, fig. 14, the Boneyard receives quantities of varied pollutants. Although Forbes & Richardson collected Johnny darters from the stream, some pollution probably existed then. According to Baker (1922:172), at the time of his study the Boneyard was receiving domestic pollutants as well as oil and tar from the gas works; pollution was extremely severe in 1915. Thompson & Hunt stated that the Boneyard contained no permanent fish population in 1928, although at that time, as well as in 1959, some fishes occasionally moved into polluted areas during high water and remained for short periods.

In 1958, black bullheads taken from the Market Street gutters during a period of high water were collected by several people and identified by Dr. Marcus S. Goldman. Apparently the fish had moved up the Boneyard, through the storm sewers, and out through the street drains. Except for similar brief ingressions, no fish occur at the present time in the Boneyard. It remains badly polluted by waste from improperly connected household drains and from businesses discharging directly into the ditch or into storm drains.

West Branch. — Although Forbes & Richardson found a variety of fishes in the West Branch of the Salt Fork during their survey, this creek has subsequently undergone drastic reduction in both va-

riety of species and abundance of individuals. The West Branch is divisible into three sections: Section 1, the 4 miles of creek above the Urbana-Champaign disposal plant; Section 2, the creek from

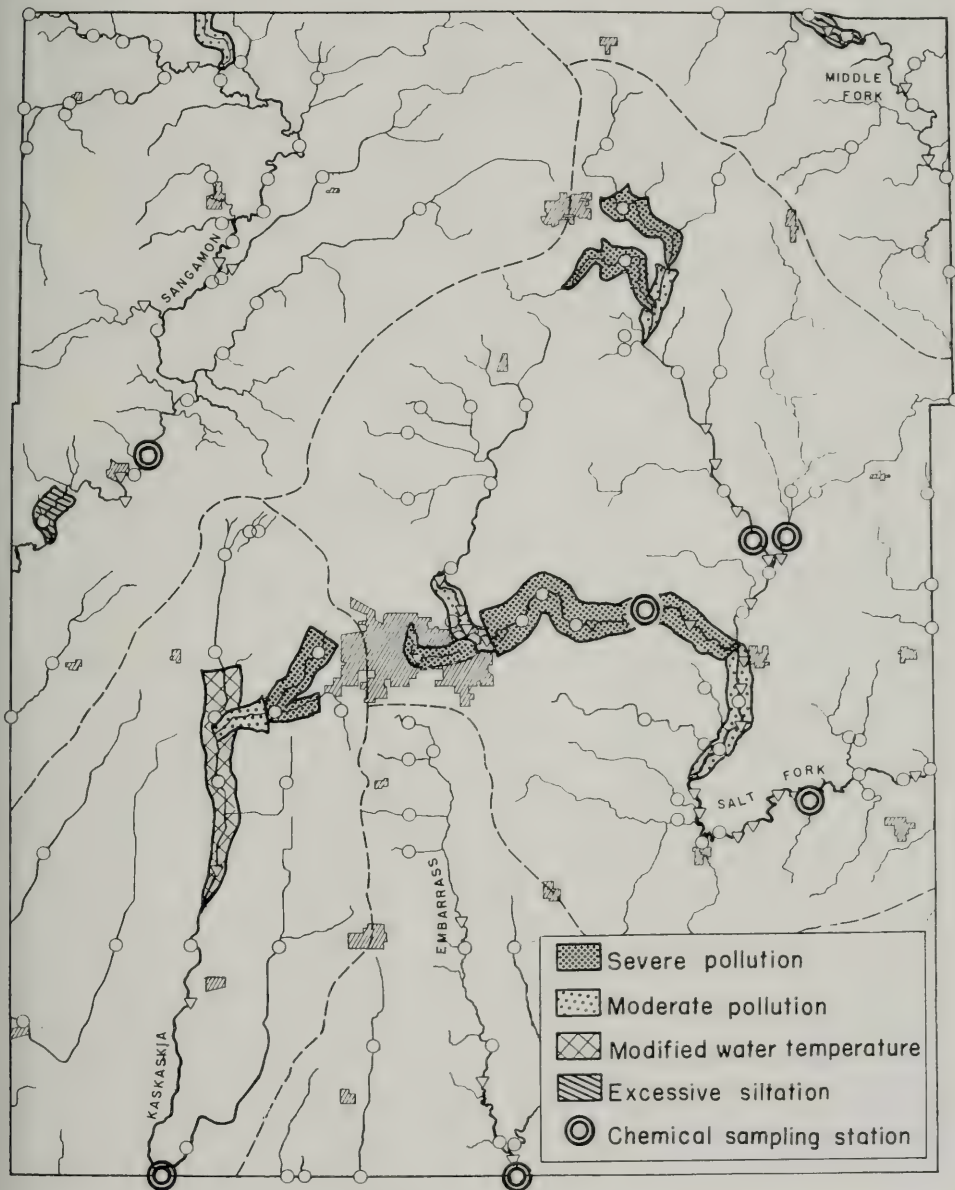


Fig. 14.—Distribution of pollution in Champaign County and location of seven stations at which chemical analyses were made in 1960. Severe pollution was found in Copper Slough and Phinney Branch west of Champaign-Urbana (city near center of map), the Boneyard in Champaign-Urbana; the West Branch of the Salt Fork east of Champaign-Urbana, the East Branch of the Salt Fork east of Rantoul (upper center of map), and the small stream from Chanute Field south of Rantoul.

the disposal plant to its junction with the East Branch; and Section 3, the stream (actually the Salt Fork) from the junction of the East and West branches downstream for a distance of 4 miles.

Section 1 presumably was relatively free of pollution when Forbes & Richardson collected at least 23 species there. In 1928, Thompson & Hunt described this section as clean and relatively free of pollution; they reported 20 species in the area. Since 1928, however, waste water from the northward expansion of Urbana and from several industrial plants has

polluted this portion of the stream. In 1959, only 15 species of fish were found there, table 24.

Examples of species that disappeared early from this section were the spotted sucker, golden redbhorse, suckermouth minnow, black bullhead, black crappie, and two species of darters. Species that disappeared in recent years (as pollution increased) were the grass pickerel, tadpole matdorn, brook silverside, and bluegill. The most notable examples of species appearing in the section for the first time after 1900 were the carp, common shiner,

Table 25.—Number of fish per 100 square yards and number of species taken at sampling stations above and below sewage disposal plant on the West Branch of the Salt Fork by Thompson & Hunt and by Larimore & Smith. Presence of a species in very small numbers is indicated by +.

STATION IN RELATION TO DISPOSAL PLANT	THOMPSON & HUNT		LARIMORE & SMITH	
	Number of Fish per 100 Square Yards	Number of Species	Number of Fish per 100 Square Yards	Number of Species
7 miles above.....	150	10	510	6
4 miles above.....	167	10	230	13
1 mile above.....	67	11	675	10
½ mile above.....	332	11	37	9
1¼ miles below.....	2	2	0	0
2¼ miles below.....	14	3	+	1
4 miles below.....	7	2	1	2
6¼ miles below.....	30	4	+	1
12 miles below.....	397	15	9	12

Table 26.—Number and weight (pounds) of fish per 100 square yards, and average number of species per station, collected in 1959 at various stations in two streams, one polluted (part of West Branch and Salt Fork) and one unpolluted (part of East Branch and Salt Fork). Each station is located with reference to stream size.

STREAM SIZE (SQUARE MILES OF DRAIN- AGE)*	POLLUTED AREA				UNPOLLUTED AREA			
	Number of Stations	Number of Species per Station	Collection per 100 Square Yards		Number of Stations	Number of Species per Station	Collection per 100 Square Yards	
			Number of Fish	Weight of Fish			Number of Fish	Weight of Fish
4-8.....	---	---	---	---	1	7	954	1.3
8-16.....	---	---	---	---	3	13	809	2.8
16-32.....	---	---	---	---	1	15	308	1.6
32-64.....	2	10	356	0.7	1	14	1,338	9.1
64-128.....	4	1	tr.	tr.	2	20	721	7.7
128-256.....	1	12	9	3.0	1	15	33	3.9

*Classification used by Thompson & Hunt (1930). In our work, we considered the numerals as designating size limits, so that a stream classified as size 4-8 had a drainage area of more than 4 and not more than 8 square miles.

Table 27.—Number of species of fish collected at several stations above and below the sewage disposal plant on the West Branch of the Salt Fork. The two pools immediately above and below the mouth of the Boneyard were one-half mile above the disposal plant.

DATE	POOL ABOVE MOUTH OF BONEYARD	POOL BELOW MOUTH OF BONEYARD	1¼ MILES BELOW SEWAGE DISPOSAL PLANT	2¼ MILES BELOW SEWAGE DISPOSAL PLANT	4 MILES BELOW SEWAGE DISPOSAL PLANT	6¼ MILES BELOW SEWAGE DISPOSAL PLANT
1959 September.....	9	4	0	1	2	1
1960 March.....	0	1	0	0	0	0
April.....	1	1	0	4	1	1
May.....	6*	6*	0	1	8	—†
June.....	1*	6*	0	0	7	6
July.....	5	7	2	0	6	9

*Heavy oil film on banks and part of water surface. †Water level too high to permit collecting.

hornyhead chub, creek chub, and redbfin shiner.

Three quantitative samples from Section 1, taken at points 4 miles, 1 mile, and one-half mile above the sewage treatment plant, table 25, indicate that several species have been able to tolerate the amount of pollution present during the past 30 years, but in 1959 the weight of fish per 100 square yards of water varied from 0.4 to 1.1 pounds, a capacity considerably below that of streams of this class (32–64 square miles of drainage) for the rest of the county, table 14.

Section 2, below the disposal plant, was already polluted at the time of the first survey. Pollution apparently had not greatly reduced the number of species present, inasmuch as Forbes & Richardson reported 33 species in the area. Soon after, however, water conditions became intolerable to most fishes (Baker 1922:117). When Thompson & Hunt collected in this 9-mile stretch, they found seven species, most of which were tolerant of moderate pollution. Only a few individuals of each species were taken, and most of these were found near outlets of drain tiles that supplied clean water. On the initial visit of the 1959 survey, the four stations that had been sampled by Thompson & Hunt produced only three species, table 24, and a total of 10 individuals. However, numerous revisits to these stations during the following spring and early summer enabled us to collect a few individuals of 12 other species.

The list of species disappearing from Section 2 is much longer than the list of species extirpated from Section 1. Species appearing for the first time in Section 2 after the advent of pollution include the carp and redbfin shiner.

The drastic reduction in the number of species, in total fish weight, and in number of individuals for Section 2 in 1959 may be seen if figures in table 26 (polluted area) are compared with county-wide averages for streams having similar drainage areas (64–128 square miles), table 14. Drastic reduction in the fish population was observed in the stream just below the disposal plant, tables 25 and 27.

Section 3 (actually the Salt Fork), a 4-mile stretch directly below the confluence of the East and West branches, receives the benefit of dilution from the cleaner East Branch. Twenty species of fish were collected in this section during the first survey, 19 in the second, and 14 in the third. The average number of fish per 100 square yards taken in the third survey was very low for streams of this size, 128–256 square miles of drainage area, table 26, but the poundage (3 pounds per 100 square yards) was about average for the county. However, the quantitative data were based on a single sample that contained 14 large carp. Species other than carp were present in very low numbers, only nine fish per 100 square yards. Signs of pollution were apparent in this section, especially at times of low water.

East Branch.—The East Branch of the Salt Fork is polluted by the city of Rantoul and by Chanute Air Force Base. At the time of the Thompson & Hunt survey, collections made near the outlet of the Rantoul sewer ditch during warm weather contained an abundance of fish of 12 species (mostly the creek chub and silverjaw minnow; the stoneroller and Johnny darter also were common). However, no fish were found at this location during the cool periods of the year. The location is presently polluted by effluent from a disposal plant placed in operation in 1954. In August, 1959, the stream below the plant was foul and the bottom was covered with sludge. It contained a few fish that were seen but not identified. The stream was revisited the following May, at which time the white sucker, stoneroller, silverjaw minnow, creek chub, and sand shiner were taken.

The Chanute Air Force Base, in the vicinity of Rantoul, operates three treatment plants that pollute a small stream flowing eastward from the southern edge of the Base. A station on this small stream contained an abundant population of 14 species at the time of the Thompson & Hunt survey, but yielded only three creek chubs and a carp when we collected there in August of 1959. The following April, when we revisited the site, it was devoid of fish.

The influence of pollution on the East Branch extends downstream several miles. Two and one-half miles below the Rantoul disposal plant, the stream smelled foul and contained other evidence of sewage in October, 1959, when a collecting station was set up there. A few specimens of the creek chub, stoneroller, silverjaw minnow, bluntnose minnow, sand shiner, and spotfin shiner were taken at this station. Two miles below, in the mouth of a small creek that flows from the air base into the East Branch, fairly large numbers of fish were taken during the same month. At this second station, all of the species listed above were collected and, in addition, the white sucker, creek chubsucker, quillback, carp, and redfin shiner. The fact that conditions looked much better at the second station than above, in either the main creek or the small branch, suggested that the organic waste, after it had been digested

and diluted, enriched the water to produce a large fish population.

Lower Salt Fork.—Thompson & Hunt considered the lower Salt Fork severely affected by pollution as far downstream as the Homer Dam near the county line; they collected only a small variety of species and found low populations at the stations in this area. In 1959, septic conditions occurred between St. Joseph and Sidney; however, between Sidney and the county line the stream appeared clear of pollution, although the water chemistry still reflected the upstream pollution, table 3. At five stations from which we took quantitative fish samples in this area, the populations were slightly below the average for streams of this size in the rest of the county, table 14.

Copper Slough, Pinney Branch.—Both branches of the small stream draining the west edge of Champaign were badly polluted in 1959. Copper Slough received industrial and domestic waste. It apparently was polluted in 1928, for Thompson & Hunt found no fish at their one station near Illinois State Route 10. Only the blackstripe topminnow was taken in Copper Slough in 1959.

In 1959, Pinney Branch received effluent from a small treatment plant located on its bank immediately above its confluence with Copper Slough. The effluent from this plant apparently prohibited existence of fish in this stream, although the pollution was probably less severe in 1959 than it was prior to the installation of the plant in 1956. At the junction of Pinney Branch and Copper Slough, a large variety of fishes was collected during the course of the 1959 survey. On February 27, 1960, no fish were seen at the junction of these two streams; perhaps the level of pollution from Copper Slough and Pinney Branch was such that it permitted the existence of fish in the lower reaches only during certain times of the year.

Upper Sangamon.—In 1959, pollution effluent from Gibson City flowed 6 miles south through Drummer Creek and entered the upper Sangamon. Domestic wastes from Gibson City and wastes from a packing plant and from a soybean mill caused fish kills in Drummer Creek and the upper Sangamon almost annually dur-

ing recent decades. According to Thompson & Hunt, wastes from a canning factory at Gibson City caused the fish kill that they described. Such kills have extended downstream as far as Mahomet. The threat of severe pollution was reduced, but not eliminated, by the recent installation of a disposal plant at Gibson City for the treatment of domestic wastes.

Upper Kaskaskia.—Alteration of the natural water temperatures of a stream may be considered a type of pollution. West of Champaign, one-half mile south of Illinois State Route 10, the U. S. Industrial Chemical Company from time to time pumps large volumes of water from three wells into the Kaskaskia for use at plants near Ficklin, 20 miles downstream. The temperature of the well water is near 55 degrees F. On July 14, 1959, at 3:00 P.M., the stream temperature above these wells was 91 degrees, at the wells 60 degrees, and the water temperature remained subnormal for 5 miles below the wells. On February 2, 1961, at 10:00 A.M., when all other streams in the county were covered by heavy ice, the Kaskaskia was open for 6 miles below the wells. The water temperature was 51 degrees at the wells, 36.5 degrees 3.5 miles downstream, and 32.5 degrees 6 miles below the wells. Large aggregations of fish and heavy algal blooms occurred in the 2 miles of stream below the wells. Besides altering temperature and producing a more constant flow seasonally, the wells also reduced the sulfate, chloride, and hardness (as CaCO_3) of the water below that of any other natural waters examined in the county, table 3. Although species composition and the distribution of fish aggregations could conceivably be altered by the well water, no such evidence was available from our collections.

Chemistry of Polluted Waters

Pollution may drastically change the amount of dissolved chemicals in water. Samples taken on the East Branch of the Salt Fork north of St. Joseph, on the West Branch east of Urbana, and on the Salt Fork northwest of Homer, fig. 14, all show the influence of domestic and commercial wastes, table 3, and are characterized by high concentrations of ammonium, nitrate, phosphate, chloride, total dis-

solved minerals, and alkyl benzene sulfonate. No consistent relationship seems to exist between alkalinity or hardness and the degree of pollution. The most striking difference between the chemistry of the water in the East Branch, where a greater than average fish population was taken, and the chemistry of the water in the West Branch, where very few fish were taken, was in the level of phosphates and sulfates present. The West Branch contained nearly four times the concentration of phosphates and twice the concentration of sulfates found in the East Branch. Concentrations of phosphates in the West Branch were presumably due to the great amount of detergents that pass through the treatment plant of the Urbana-Champaign Sanitary District. Alkyl benzene sulfonate, one of the basic ingredients in most household detergents, was nearly twice as concentrated in the West Branch as in the East Branch.

Fish Anomalies Caused by Pollution

Many malformed fishes were taken from the West Branch of the Salt Fork above the sanitary disposal plant. Although fair numbers of individuals were taken in these collections, table 25, the fish were small in size and many of them had abnormally small, upturned mouths; certain fins were partially or entirely missing. The creek chub, bluntnose, and common shiner seemed to be especially affected. They may be the only species that can reproduce in the polluted water, and hence, in their embryonic development, they may have been influenced by toxic substances.

Fish Kills

Mention has been made of fish kills in Champaign County. A kill of fish has been observed annually for many years on the upper Sangamon River. Dead fish have been reported as far downstream as Mahomet. A severe kill occurred during the middle of August in 1959 while we were engaged in the third survey. Dead fish were found in the upper Sangamon from the mouth of Drummer Creek downstream as far as the town of Fisher. Along the banks 3 miles north of Fisher, 21 species were identified. Dead mussels, crayfish, tadpoles, and salamanders (*Necturus*)

also were found. The proportion of the fish population killed by this pollutant was not known. The dead fish picked up and examined represented most of the species previously taken in our collections. In spite of the recurring kills, the disappearance of only one species is attributed to this pollution. A minnow (*Notropis amnis*), taken at three stations in the Sangamon near Fisher by Thompson & Hunt, seemingly no longer occurs in the county.

On the upper Kaskaskia, severe pollution introduced at a point just south of Champaign County near Ficklin has produced chronic toxic conditions and frequent fish kills. The Ficklin pollution probably blocks the upstream movements of certain species and thus influences the composition of the populations within Champaign County.

The East Branch has had several fish kills in recent years other than those caused by domestic pollution from Rantoul and Chanute Air Force Base. One such kill was said to have been caused by the accidental release of a large volume of gasoline into the stream. Another kill resulted from discharge into the stream of solutions used for cleaning aircraft.

On the West Branch, an occasional dead fish can be found, although so few fish occur in the area below the disposal plant that even if all were killed there would not be a noticeable number of dead individuals along the banks. Probably the fish found dead were individuals that moved into this area when water conditions were temporarily tolerable and were killed as conditions again became lethal.

In the lower Salt Fork, fish kills frequently have occurred below St. Joseph. These probably have been the result of overenrichment of the waters, where near-pollution conditions are usually present. Summer fish kills seem to be associated with periods of very low water levels and high temperatures; during such periods septic conditions develop. Often in the wintertime, blooms of green plants and animals develop that cause the death of fish over a long stretch of the river. Very heavy algal blooms developed during February and March of 1954. An abnormally low amount of suspended silt was in the

water when there developed a tremendous green bloom composed mainly of *Euglena* sp. (similar to *E. sanguinea*) and a diatom, *Hantzschia amphioxus* (identification by Dr. P. C. Silva, then Associate Professor of Botany, University of Illinois). The organisms settled to the bottom of the stream each day after dark and blanketed the bottom materials. Many fish were seen gasping along the shoreline of the river and in small tributary water sources. Dead fish could be seen all along the river from St. Joseph as far downstream as Fairmount in Vermilion County. These water conditions not only killed many fish but caused the flesh of surviving fish to be unpalatable.

Ingression Into Polluted Waters

During the spring and early summer of 1960, we made a series of seine hauls at the West Branch stations sampled the previous September. These seine hauls indicated a certain amount of ingression of fishes into polluted water, table 27. The several species taken below the disposal plant were represented by very few individuals. The creek chub, bluntnose minnow, redbfin shiner, and golden shiner were the species most frequently taken in these collections.

Reinvasion of a stream area by species once present is usually very rapid (Larimore, Childers, & Heckrotte 1960:269); if chemical conditions below the disposal plant were made suitable for the existence of fish, the population would quickly build up to what might be expected in streams of similar size.

Specific Tolerance to Pollution

The following species were most frequently found in the polluted water areas sampled in 1959: creek chub, carp, silverjaw minnow, bluntnose minnow, redbfin shiner, golden shiner, stoneroller, green sunfish, sand shiner, common shiner, spotfin shiner, white sucker, creek chubsucker, topminnow, Johnny darter, and hornyhead chub. The finding of a particular species in a polluted area did not necessarily mean that this species was more pollution-tolerant than other species. Species found in a polluted area may have been unusually vagile, moving into the area during periods of improved water conditions; equal-

ly pollution-tolerant species might have been absent because they did not occur in the drainage system, because suitable habitat was not available, or because they were more sedentary in habits. The above list of pollution-tolerant species contains most of the species listed as tolerant by Thompson & Hunt.

DISTRIBUTION AND WATER ENRICHMENT

Stream enrichment is a vaguely defined condition in which some of the dissolved chemical constituents of the water are greater in amount than would normally occur from contact with the soil in a particular drainage system or region. Enrichment of a body of water should result in greater productivity of aquatic organisms. However, because aquatic organisms have rather specific requirements, enrichment may produce conditions inimical to their very existence. Enrichment to some organisms is pollution to others.

Champaign County streams are enriched by minerals leached from the soils of the drainage area, by fertilizers added to soils for increased crop production, by wastes from livestock, and by domestic sewage. Wastes from commercial operations could also contribute enriching materials, although no instance of such enrichment is known to occur in this county.

Natural Soil Fertility

The soils of Champaign County are unusually fertile and contribute dissolved nutrients to the streams draining them. The chemical composition of the waters, table 3, has been discussed previously.

Thompson & Hunt assumed that the size of a fish population was related to soil fertility because they found the largest concentration of fishes in the East Branch of the Salt Fork River, which flows through an area that they regarded as more fertile than any other in the county. Presently available information on the soils of Champaign County does not indicate that the streams in this drainage flow through an area more fertile than other drainage areas of the county. At only three of our collecting stations on the East Branch was the weight of fish per 100 square yards much greater than the average for the county, tables 14 and 26.

Alkalinity and total hardness have often been related to high productivity in natural waters. All of the streams in the county are slightly alkaline and rather hard. The water in one of the two main streams in the East Branch drainage, the Spoon River, is the hardest in the county and one of the most alkaline, whereas water in the other stream is the least alkaline and near average in hardness, table 3. Because of differences in chemical composition of these streams, which produced several large fish collections and were regarded by Thompson & Hunt as especially fertile, it is difficult to relate fish productivity to soil or water fertility. The differences between these streams appear to be more the result of domestic pollution than of soil characteristics in the drainage area.

Fertilizers on the Watershed

Commercial fertilizers are used by farmers on virtually all of the croplands of Champaign County. The amount of fertilizer that enters the streams is influenced by the natural soil chemistry, the soil permeability, the land use, the kind and amount of fertilizer applied, and other factors that make an exact determination difficult.

Large amounts of organic fertilizer in the form of livestock manure are applied by farmers to most of the watersheds. The droppings of grazing cattle and hogs are deposited in pastures, often along stream banks, and sometimes actually in the streams. In some areas, manure contributes substantially to the fertility of the streams. An excess of fertilizer can cause fish mortality during the hot summer months when the water levels are unusually low, but, in Champaign County, instances of damage caused by excess amounts of livestock manure are probably rare. Damage is done by livestock when the animals break down stream banks, permitting excessive amounts of silt to enter water courses.

Domestic Sewage

Domestic sewage can be related to stream productivity in several places in Champaign County. Thompson & Hunt in 1928 found a fish population in the East Branch apparently benefiting from

enrichment of stream water by the domestic sewage of Rantoul. At that time, Rantoul did not treat sewage but allowed it to run through an open ditch where, during warm weather, it was well digested before entering the East Branch. On revisiting the station during a cooler part of the year, Thompson & Hunt found that the raw sewage was not digested in the open ditch but that it entered the East Branch as toxic material that eliminated fish for several miles downstream.

At present, there is evidence of enrichment of the East Branch by domestic sewage from Rantoul and Chanute Air Force Base. For several miles below the outlets, this sewage is toxic to fish most of the time. Farther downstream, large populations of a wide variety of fishes benefit from the end-products of the sewage that has been digested upstream. At one station with 41 square miles of drainage, 7.2 miles below the Rantoul disposal plant and approximately 2 miles below the entrance of the badly polluted stream from Chanute, the collection per 100 square yards amounted to 1,337 fish weighing more than 9 pounds. At another station with 73 square miles of drainage, 4.5 miles farther downstream, the collection per 100 square yards amounted to 1,331 fish weighing more than 10.5 pounds. These figures, three to four times the county averages, table 14, represented an area a few miles below the badly polluted area in which very few fish were found.

A fish population possibly benefiting from stream enrichment was taken in the upper Sangamon River about a mile below the mouth of Drummer Creek, which receives pollution from several sources in Gibson City. In this population, the numbers of individuals of the 22 species represented were low, but their sizes were sufficiently large to make the collection average 5.6 pounds per 100 square yards, a weight nearly twice that for most other streams of this size (193 square miles of drainage) in the county, table 14.

An instance that may be considered partial enrichment was found west of Champaign on Phinney Branch at the junction of Copper Slough. The upper

regions of both Phinney Branch and Copper Slough were polluted, but where they converge 20 species were taken; the collection averaged 2.6 pounds per 100 square yards of drainage. Although 20 is an unusually high number of species for streams of this class (16 square miles of drainage) in the county, the weight was not much above average, table 14.

The Salt Fork from St. Joseph to the county line was the longest stretch of stream in the county enriched by upstream sewage. However, our collections failed to indicate any desirable effects of the enrichment.

Where fishes are benefiting from enrichment of the water, they may be existing under conditions that with very slight changes in chemical balance and concentration can quickly become toxic to them. Our data show that when desirable enrichment changes to undesirable pollution the effects on a fish population are first a reduction in the number of species, then a reduction in the total weight, and finally a reduction in the number of individuals.

FISHERIES

The network of streams and a scattering of artificial ponds and lakes provide a considerable amount of fishing water in Champaign County. All of the streams, except the Little Vermilion and Embarrass, are listed in the Game and Fish Codes as fish preserves; that is, fishing is restricted to hook-and-line methods, or to minnow seining and spearing as provided by the Game and Fish Codes. Public access to most of the streams is provided by the system of section-line roads, and fishing is generally heaviest near bridges. All the waters as well as the stream banks are privately owned; fishermen must obtain landowners' consent to enter the property.

Sport Fishing

Approximately 20 of the 90 species in the annotated list of the fishes of Champaign County are commonly taken by hook-and-line fishing. However, Dr. Marcus S. Goldman has caught 38 species. The 189 miles we have classed as Rivulets and Small Creeks provide satisfactory angling only for small boys in quest of

chubs, sunfishes, or bullheads. The 176 miles of Large Creeks provide good fishing for anglers interested in catching chubs, sunfishes, bullheads, and, in the spring, a variety of suckers. The 58 miles of Small Rivers produce large numbers of suckers, sunfishes, bass, carp, and catfishes. The lower Sangamon River is an especially good fishing area for channel catfish, suckers, and carp, and, according to Dr. Goldman, offers a better opportunity for angling than any other stream in the county. The lower Salt Fork is good for suckers and carp; channel catfish become important a few miles before the stream leaves the county. The Middle Fork in Champaign County produces three species of bass and the channel catfish.

Creek chubs, hornyhead chubs, black bullheads, yellow bullheads, several sunfishes, and many species of suckers can be taken in most streams of the county. The most commonly used baits are worms, minnows, crayfish, and especially prepared cheese baits, blood baits, and doughballs; relatively little casting is done with artificial lures.

Approximately 125 ponds and small lakes provide angling. These waters are formed by artificial dams and by flooded gravel and borrow pits. Most of the ponds are privately owned.

The fishes commonly found in these ponds are the bluegill, green sunfish, redear sunfish, orangespotted sunfish, warmouth, black crappie, white crappie, largemouth bass, black bullhead, yellow bullhead, channel catfish, golden shiner, and bluntnose minnow.

Commercialized Sport Fishing

Three privately owned lakes in Champaign County have been licensed to operate as daily fee-fishing ponds. Great numbers of fish are purchased from commercial fishermen and fish dealers along the Mississippi and Illinois rivers, on some northern lakes, and even on Lake Erie as far east as Ohio. These fish are hauled alive by truck and released in the fishing ponds at intervals during the fishing season. Anglers pay a daily fee to fish. Because the fish are of many species and because some are brought from distant waters, the ponds are potential sources of species new to the streams of

the county. The following species have been taken from Champaign County fee-fishing ponds: bowfin, bluegill, green sunfish, white crappie, yellow bass, carp, channel catfish, brown bullhead, yellow bullhead, black bullhead, largemouth bass, quillback, gizzard shad, goldfish, and a few minnows that probably were not deliberately introduced by the pond owners.

Bait Collecting

Large numbers of minnows suitable for fish bait may be taken from many reaches of Champaign County streams. Crayfish also are taken from the streams.

Although in 1959 there were no licensed wholesale minnow dealers in Champaign County, there were eight retail minnow dealers who sold minnows to sport fishermen. Their minnow supplies were either purchased from sources outside the county or were seined by the dealers themselves from local streams. Because of the great labor and cost involved in procuring a sufficient number of minnows from local streams, most dealers found it more economical to purchase stocks from wholesale dealers.

Many fishermen take relatively small numbers of minnows for their own use. They may take bait from the streams without a commercial fishing license in seines not larger than 6 feet deep and 20 feet long and having a mesh of one-half inch or less. Many fishermen have favorite minnow "holes" where they can seine enough minnows for a 1-day fishing trip. Such small-scale bait collecting is a justifiable use of minnows and does not endanger the natural populations.

SUMMARY

1. Two investigations of fishes in the streams of Champaign County, Illinois, investigations approximately 30 years apart (modal years 1899 and 1928), provided an incentive for a third investigation, in 1959, aimed at evaluating the effects of ecological changes that occurred over a period of approximately 60 years in an area that included both intensive farming and urbanization.

2. In less than a century, most of Champaign County was converted from marshy prairie to well-drained farmland. In recent years, population growth and

industrial development have usurped a considerable acreage of the farmland.

3. Draining and dredging reduced the water-holding capacity of the watersheds, resulting in a lower water table and in extreme fluctuations in stream flow. Canalization altered stream courses and habitats and produced more uniformity in stream environments.

4. Late in the nineteenth century, most of the marshes and natural ponds were eliminated; many drainage ditches were created. During the 30 years ending in 1959, the environmental trends in the streams were toward a decrease in depth and an increase in width; a decrease in gravel substrate, an increase in silt, and an increase in sand; a decrease in aquatic vegetation and an increase in overhanging vegetation.

5. Ninety species of fishes were included in the annotated list for Champaign County; 74 of these were taken in 1959 or subsequently. Seven of the 90 were introduced species; the remaining 83, some of them no longer in the county, were native.

6. Sixteen species, the introductions excluded, showed a decided increase in occurrence (number of collecting stations and number of stream systems in which they were found) within the county during the 60-year period of study; 15 other species showed a decided decrease in occurrence. Many species showed little change in occurrence, despite the great changes that took place in the stream habitats.

7. During the early part of the present century, the Salt Fork drainage contained a greater number of species than any other drainage in Champaign County; it was followed by the Sangamon, Middle Fork, Kaskaskia, and Embarrass. Subsequently, the Salt Fork and Sangamon exchanged rank. In 1959, the Sangamon contained the greatest number of species restricted to one drainage; the Embarrass had no species that occurred in that stream exclusively.

8. Much greater changes in species composition occurred in Champaign County streams during the first 30 years of the twentieth century than during the second 30 years. During the first 30-year period, the greatest changes occurred in the Middle Fork and Sangamon

drainages; during the second 30-year period, the greatest changes occurred in the Kaskaskia and Salt Fork drainages.

9. Champaign County streams were classified as rivulets and small creeks, large creeks, and small rivers. Both large creeks and small rivers contained the following habitats: sand and fine gravel riffles; gravel and boulder or rubble riffles; shallow, firm-bottomed pools; and deep, mud-bottomed pools. Each habitat was found to have characteristic species of fishes.

10. Each factor in the habitat of a species was expressed mathematically by correlating the numbers and weights of each species taken in quantitative samples with the numerical value for each of 13 different ecological factors.

11. Significant degrees of association, some of which were unexpected, were found between the numerical abundance of *Notropis dorsalis* and *Ericymba buccata*, *Notropis chrysocephalus* and *Erimyzon oblongus*, and *Catostomus commersoni* and *Phenacobius mirabilis*. Less significant associations were found between each of these species and several other species and between a few other pairs of species. A mutual dependence upon certain ecological conditions, rather than a direct interdependence between species, appeared to account for the associations found in Champaign County.

12. The average number of species per collecting station and the average number of fish per 100 square yards of water were somewhat greater in 1959 than in 1928. The most pronounced differences in the number of fish per unit area occurred in the Middle Fork drainage (high in 1928, low in 1959) and the Embarrass (low in 1928, high in 1959). The number of pounds of fish per acre of water was found to be 124.4 in 1959; it had been estimated by Thompson & Hunt to be 150 in 1928. The number of pounds of fish per 100 square yards of water in 1959 averaged 2.6, ranging from 0.9 in the Kaskaskia to 5.1 in the Middle Fork drainage.

13. The following generalizations between fish distribution and stream size, as postulated by Thompson & Hunt (1930) following the 1928 investigation, were in general borne out in the 1959 study: the

number of species per station increased downstream; the actual number of fish per unit area decreased downstream; and, with a decrease in the number of individuals downstream, there was a corresponding increase in their average size, so that the total amount of fish flesh per unit area was nearly constant. Thompson & Hunt's statement that fishes exhibit frequencies of occurrence that vary with stream size in a consistent and definite manner for each species was not substantiated with the 1959 data. Their hypothesis that the amount of fish flesh per unit of water was directly related to fertility of the water was neither confirmed nor disproved by the 1959 data, probably because all streams of the county were of nearly equal fertility.

14. The degree of stream pollution in Champaign County was greater in 1928 than in 1899, and greater in 1959 than in 1928. Although certain types of pollutants common in 1899 and 1928 no longer existed in 1959, other types had replaced them. The large and increasing volume of treated effluents limited aquatic life in many areas of Champaign County streams at the time of the third survey. Pollution had caused a decline, even elimination, of fish in some reaches.

15. In 1959, chronic pollution in Champaign County was found to occur in the Boneyard, parts of the East Branch and West Branch of the Salt Fork, the lower Salt Fork, Copper Slough and Phinney Branch, the upper Sangamon, and the upper Kaskaskia. Some of these areas had been polluted for many years; others had recently become polluted.

16. Champaign County streams are enriched by natural soil fertility and a variety of introduced substances. Evidence was found in 1959 that certain fish populations were benefiting from enrichment. Slight changes in chemical balance and concentration may quickly convert enriched areas to polluted ones.

17. Champaign County contains a considerable amount of water useful for fishing. In addition to the streams, there are farm ponds, artificial lakes, and fee-fishing ponds available. Public access to the fishing sites is generally adequate, although streams are privately owned and landowners' permission must be obtained. Approximately 20 of the 90 species of fish known in the county are commonly taken by angling. Noncommercial minnow seining for bait is a justifiable use of the local fauna and does not jeopardize local minnow populations.

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SPECIES DISTRIBUTION MAPS

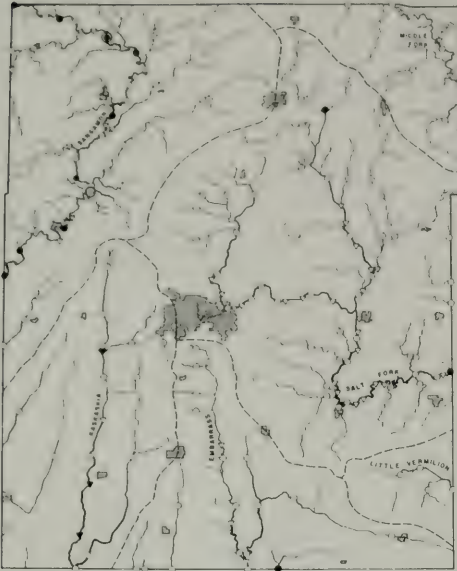


Fig. 15.—*Dorosoma cepedianum*.

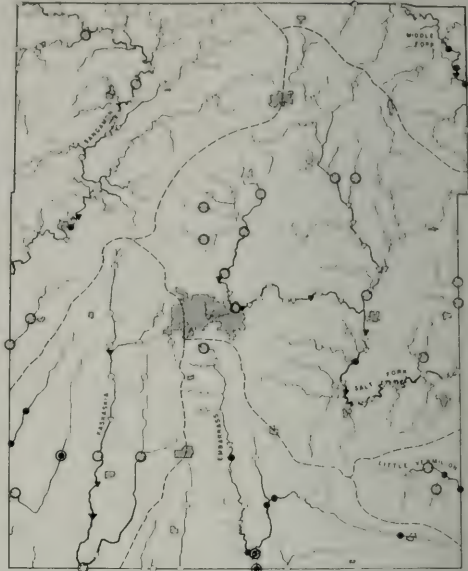


Fig. 16.—*Esox americanus*.

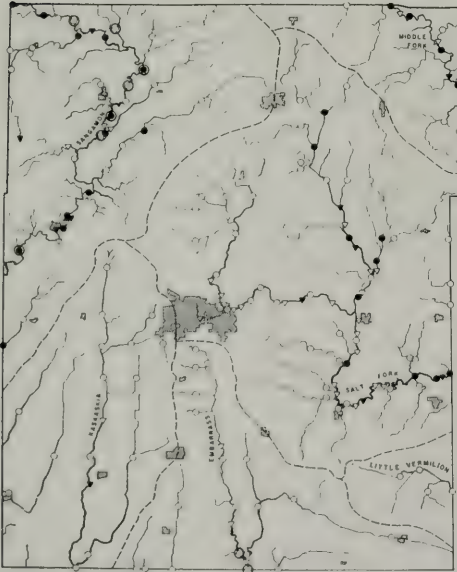


Fig. 17.—*Carpiodes cyprinus*.

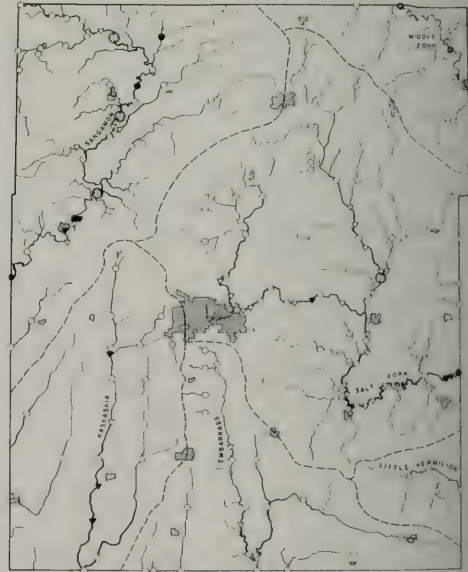
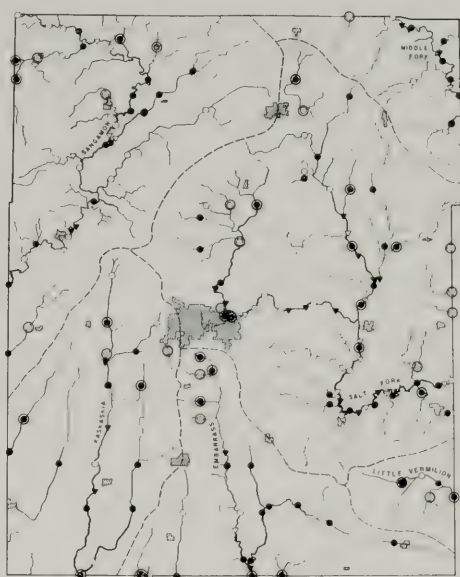
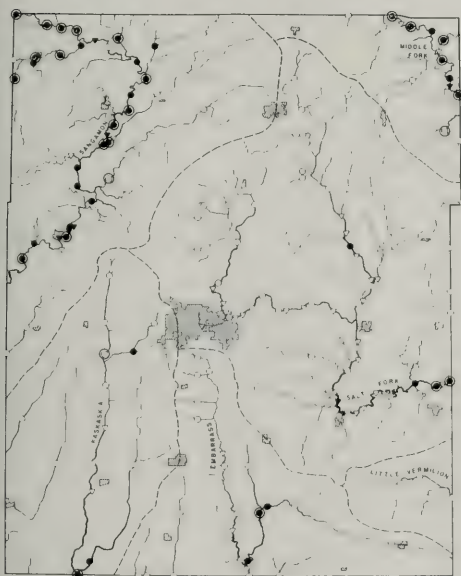
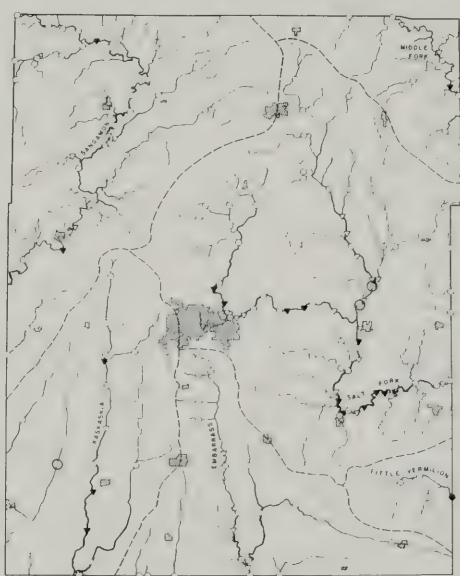


Fig. 18.—*Carpiodes velifer*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

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Fig. 19.—*Catostomus commersoni*.Fig. 20.—*Erimyzon oblongus*.Fig. 21.—*Hypentelium nigricans*.Fig. 22.—*Minytrema melanops*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

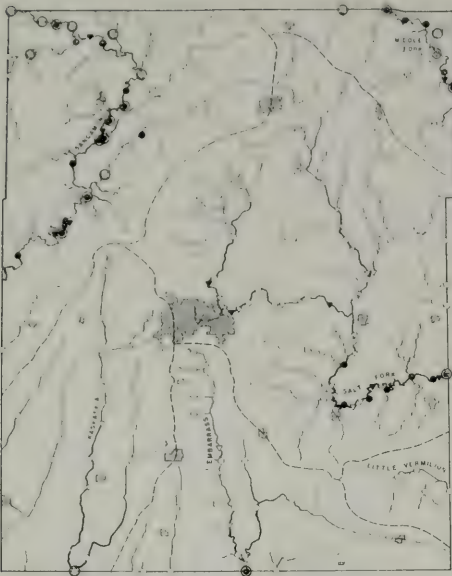
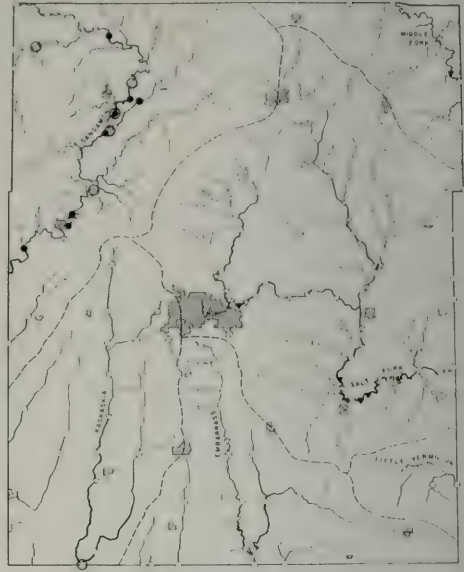
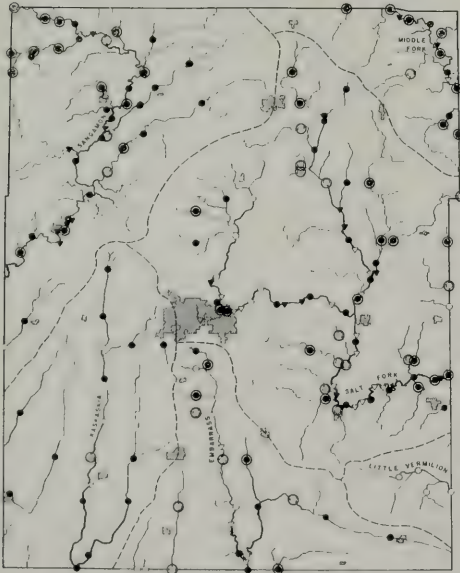
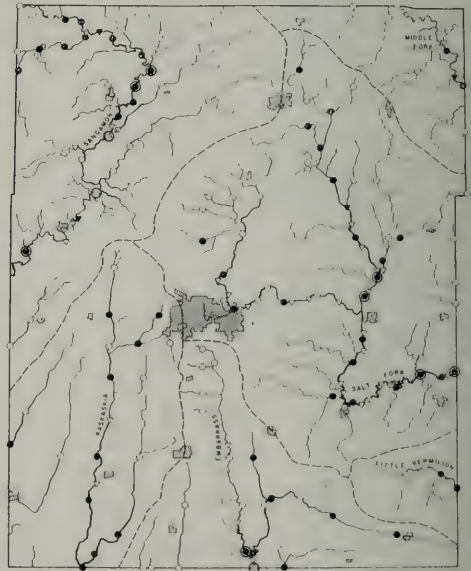
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Fig. 23.—*Moxostoma erythrurum*.Fig. 24.—*Moxostoma macrolepidotum*.Fig. 25.—*Campostoma anomalum*.Fig. 26.—*Cyprinus carpio*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

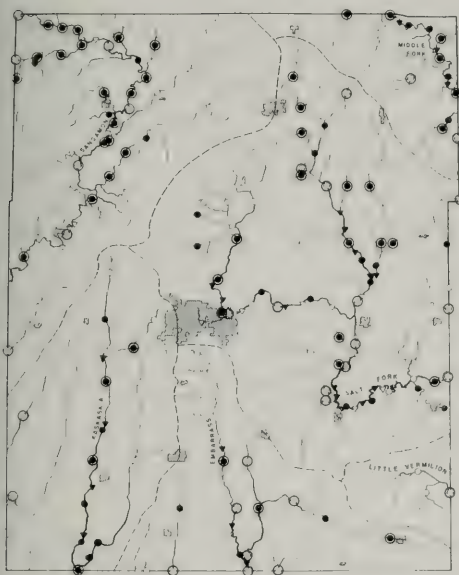
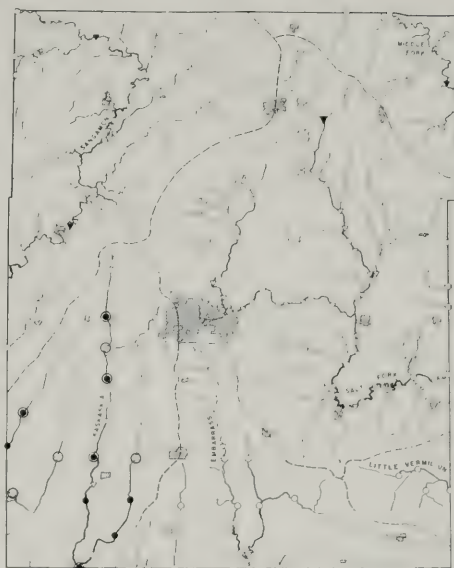
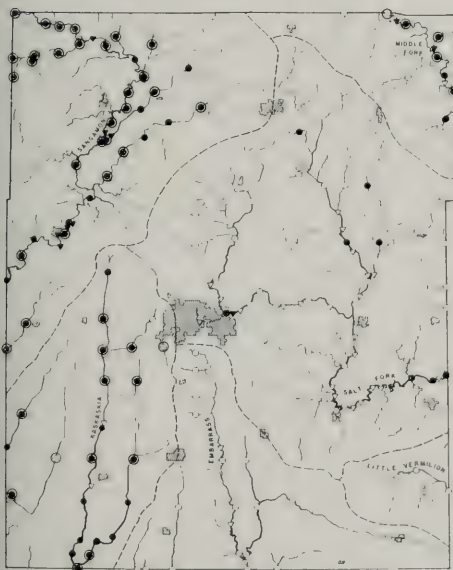
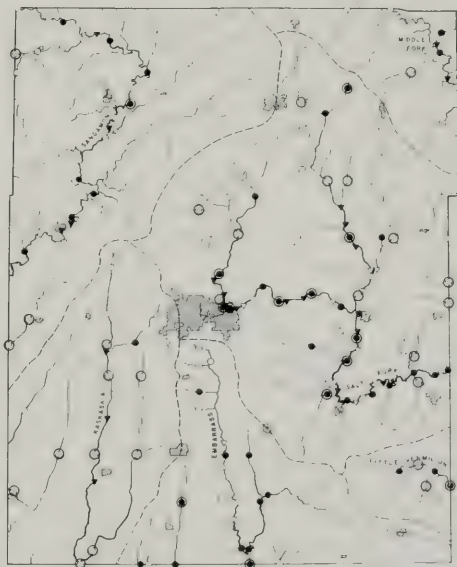
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Fig. 27.—*Ericymba buccata*.Fig. 28.—*Hybognathus nuchalis*.Fig. 29.—*Hybopsis biguttata*.Fig. 30.—*Notemigonus crysoleucas*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

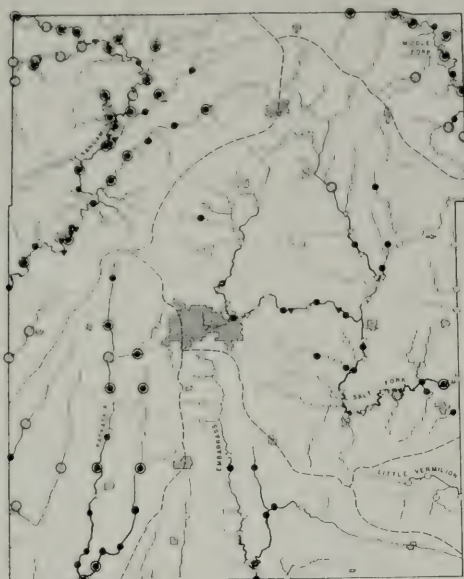
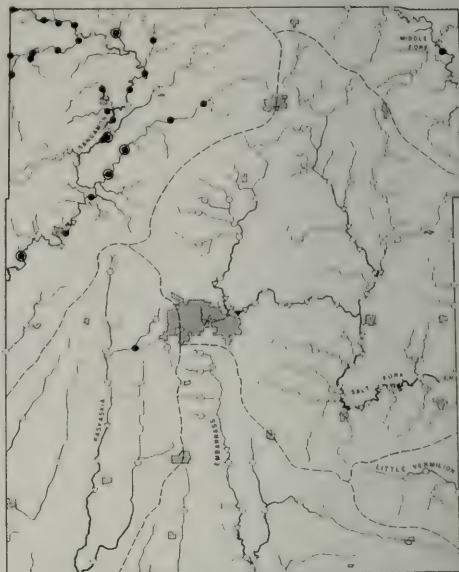
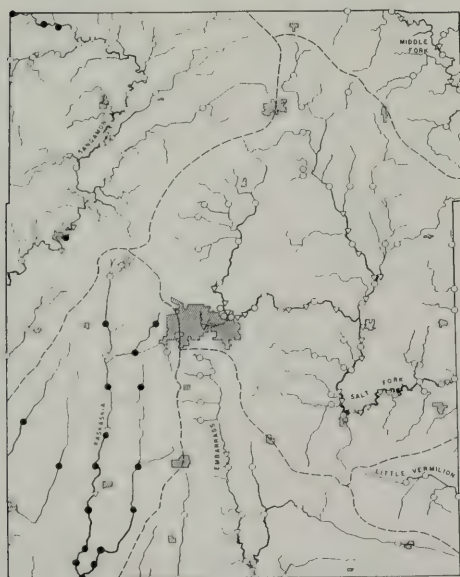
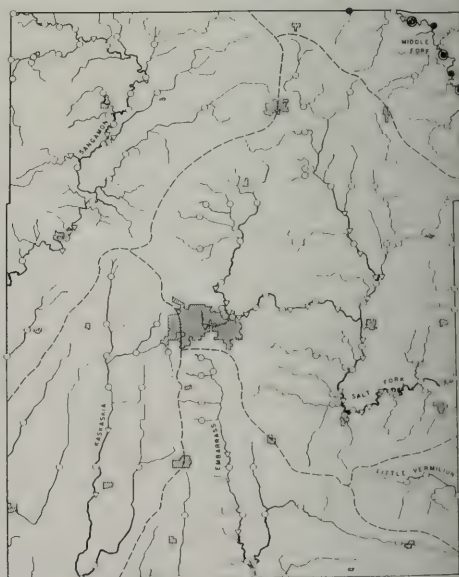
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Fig. 31.—*Notropis chrysocephalus*.Fig. 32.—*Notropis dorsalis*.Fig. 33.—*Notropis lutrensis*.Fig. 34.—*Notropis rubellus*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

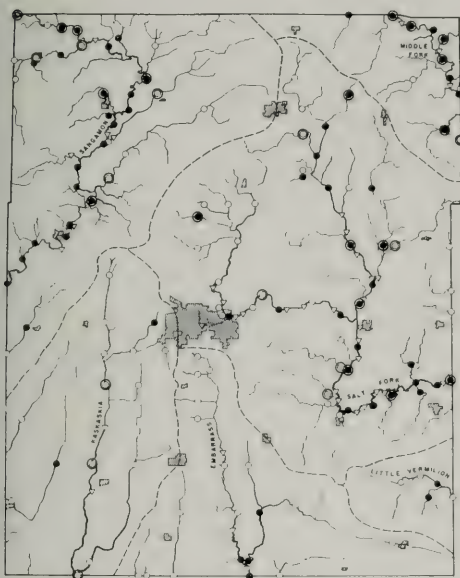
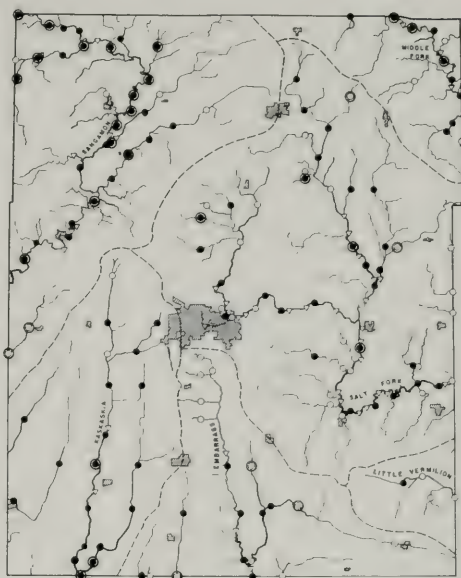
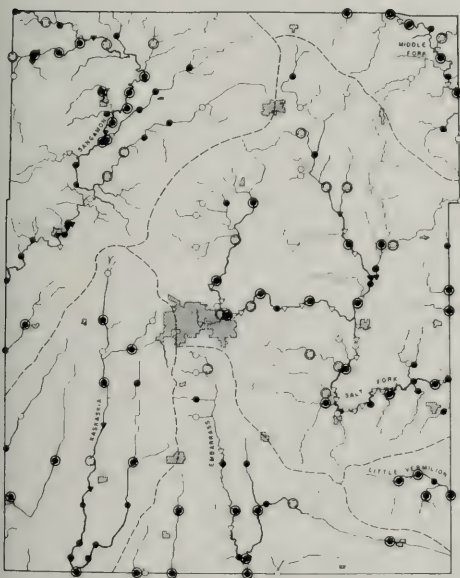
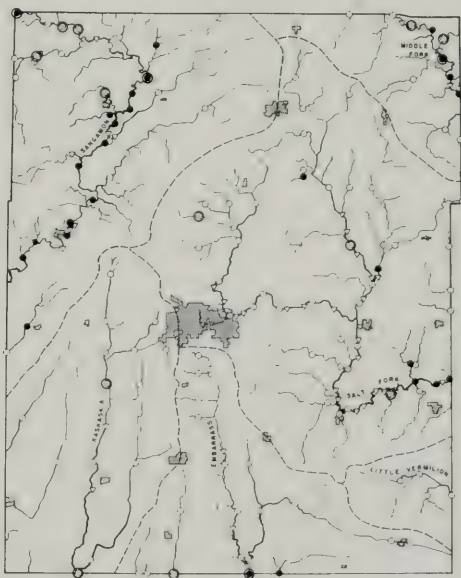
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Fig. 35.—*Notropis spilopterus*.Fig. 36.—*Notropis stramineus*.Fig. 37.—*Notropis umbratilis*.Fig. 38.—*Notropis whipplei*.

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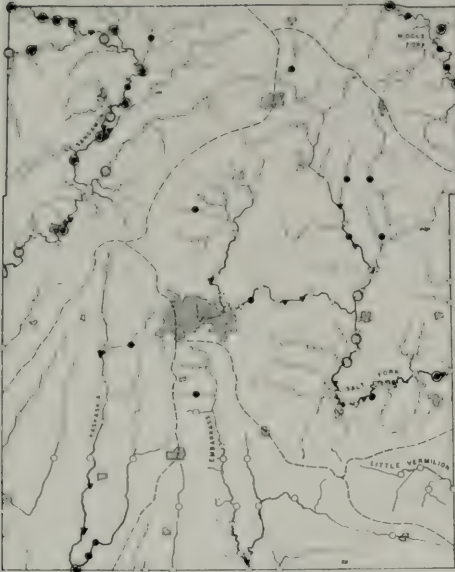


Fig. 39.—*Phenacobius mirabilis*.

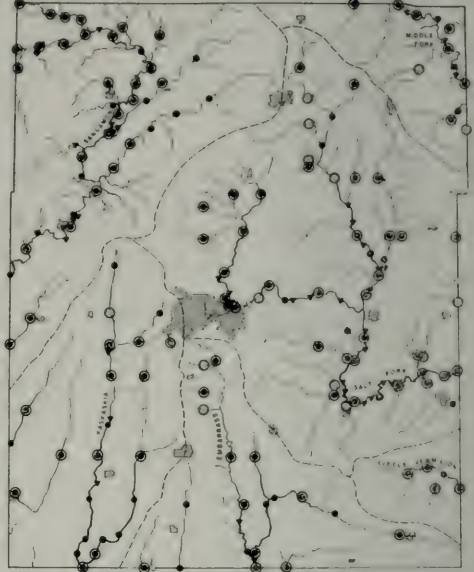


Fig. 40.—*Pimephales notatus*.

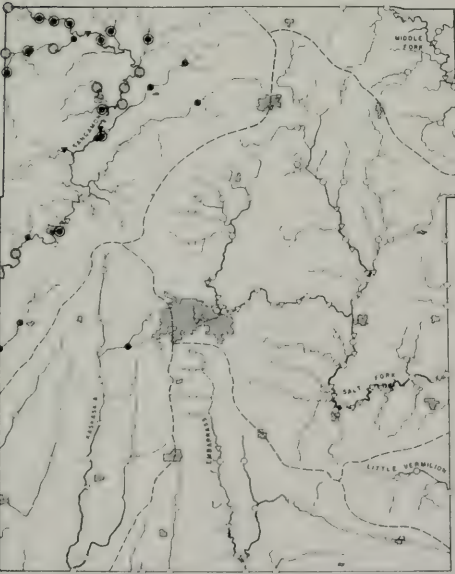


Fig. 41.—*Pimephales promelas*.

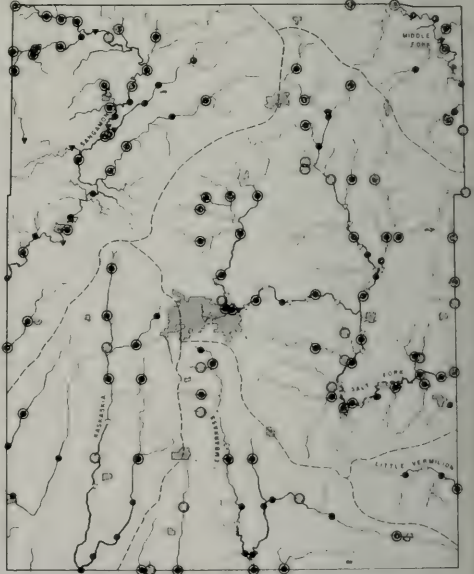
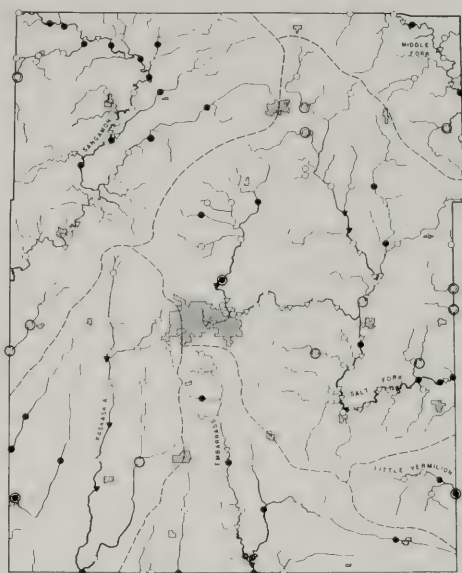
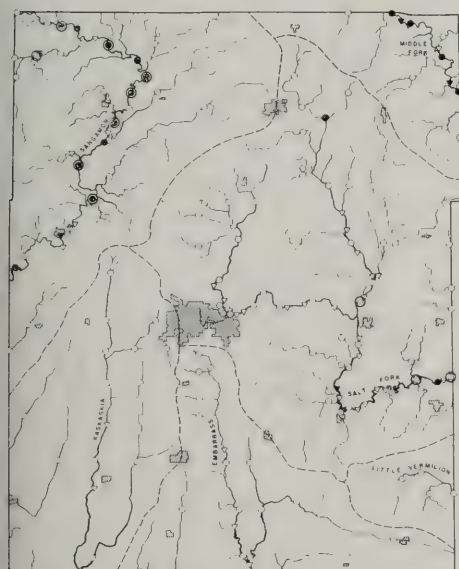
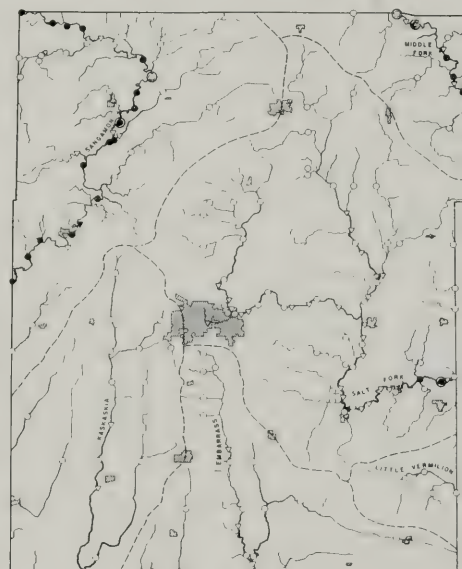


Fig. 42.—*Semotilus atromaculatus*.

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Fig. 43.—*Ictalurus melas*.Fig. 44.—*Ictalurus natalis*.Fig. 45.—*Ictalurus punctatus*.Fig. 46.—*Noturus flavus*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

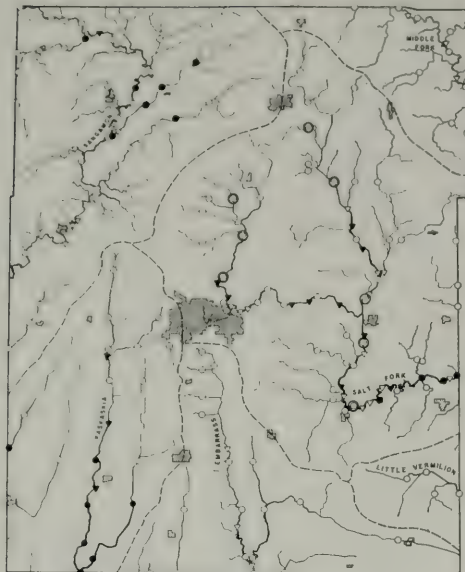
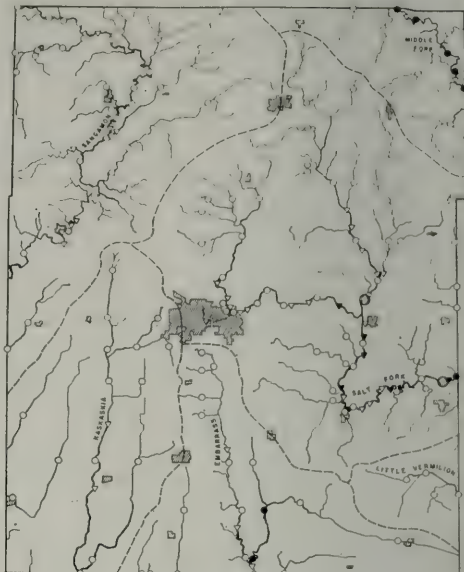
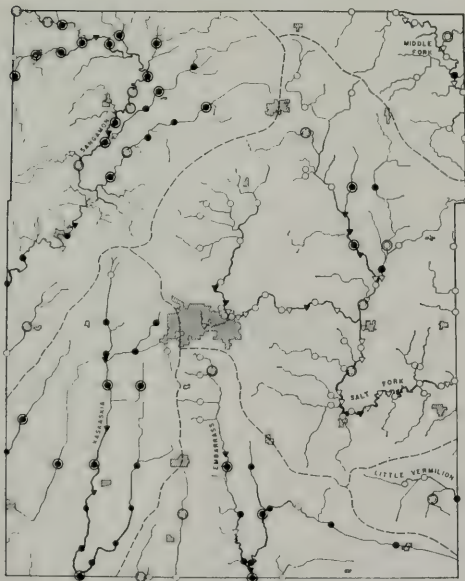
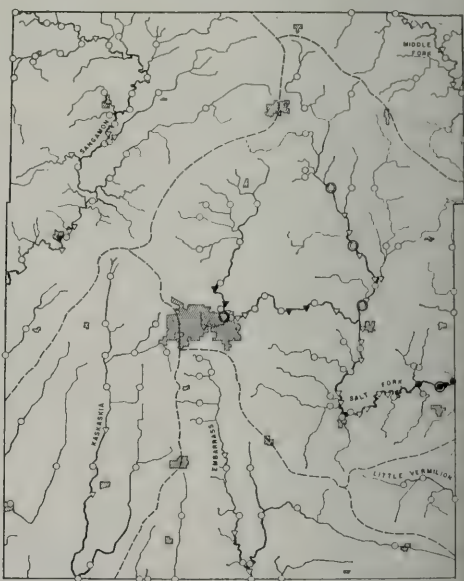
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Fig. 47.—*Noturus gyrinus*.Fig. 48.—*Noturus miurus*.Fig. 49.—*Fundulus notatus*.Fig. 50.—*Labidesthes sicculus*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

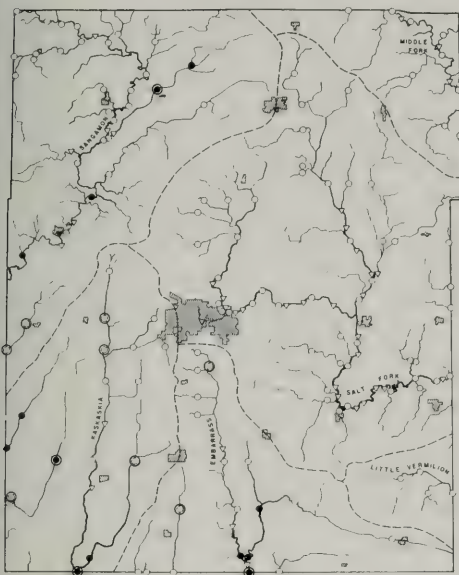
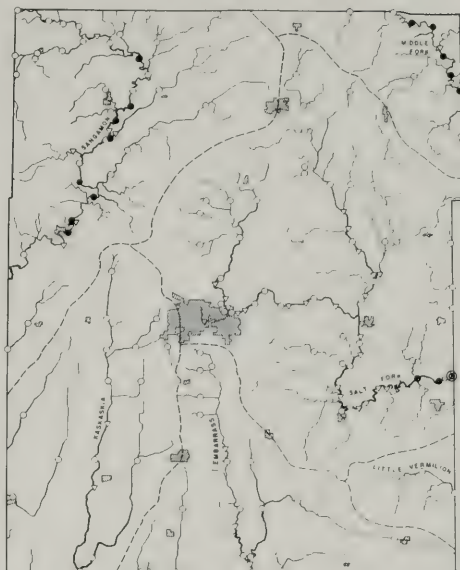
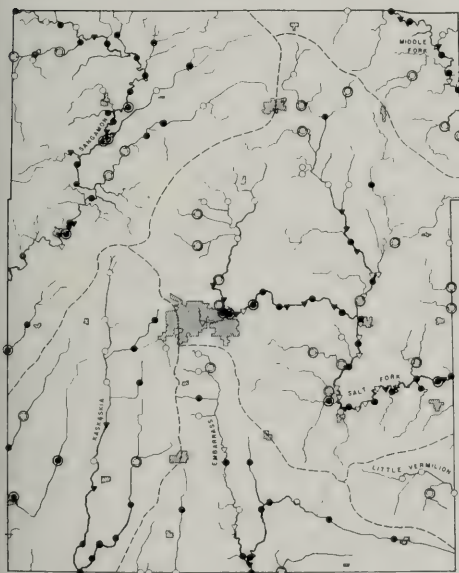
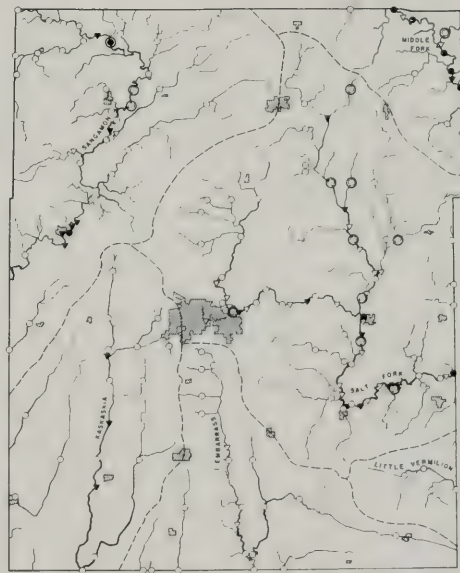
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Fig. 51.—*Aphredoderus sayanus*.Fig. 52.—*Ambloplites rupestris*.Fig. 53.—*Lepomis cyanellus*.Fig. 54.—*Lepomis humilis*.

Distribution of Champaign County fishes as determined by three surveys at approximately 30-year intervals.

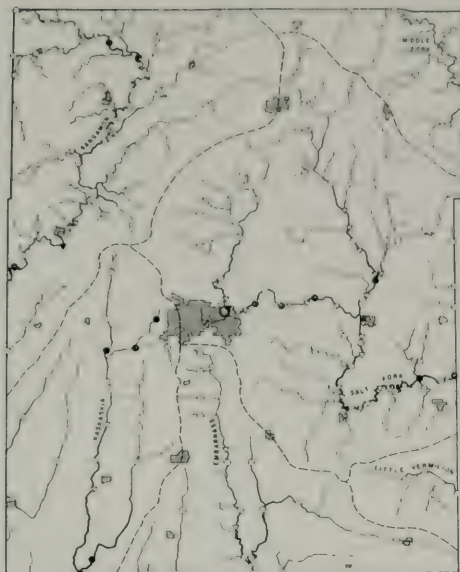
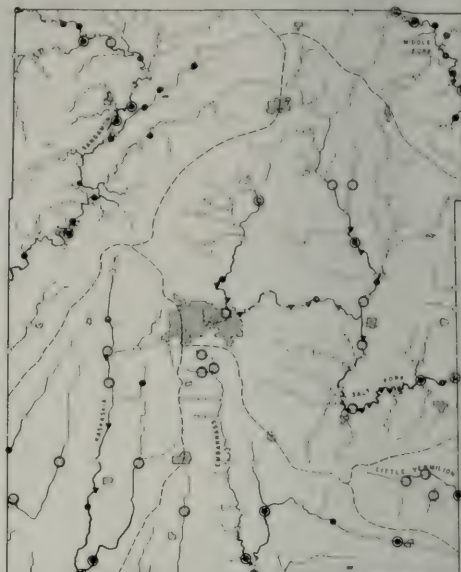
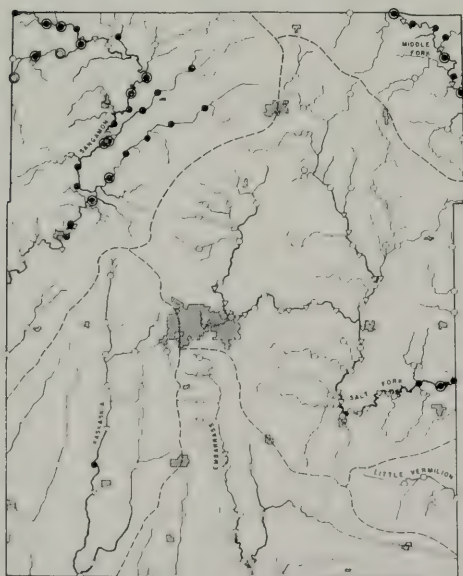
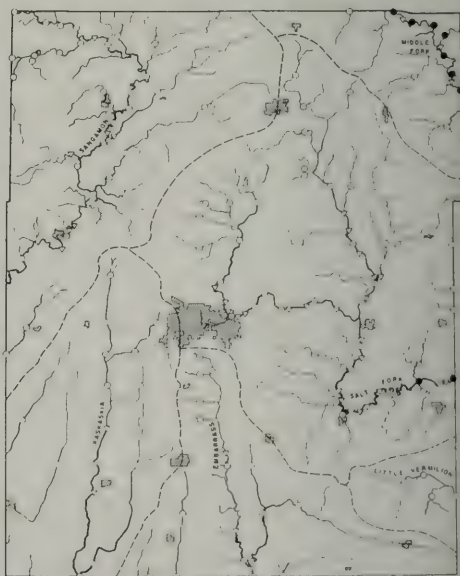
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Fig. 55.—*Lepomis macrochirus*.Fig. 56.—*Lepomis megalotis*.Fig. 57.—*Micropterus dolomieu*.Fig. 58.—*Micropterus punctulatus*.

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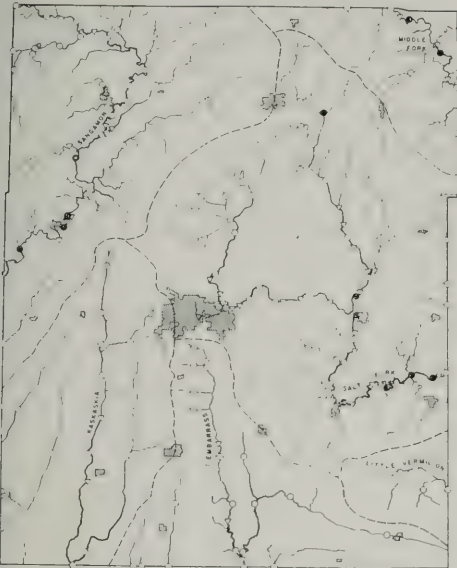


Fig. 59.—*Micropterus salmoides*.

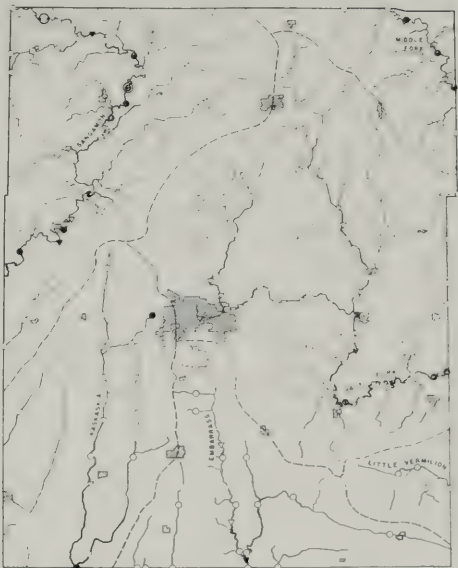


Fig. 60.—*Pomoxis annularis*.



Fig. 61.—*Ammocrypta pellucida*.

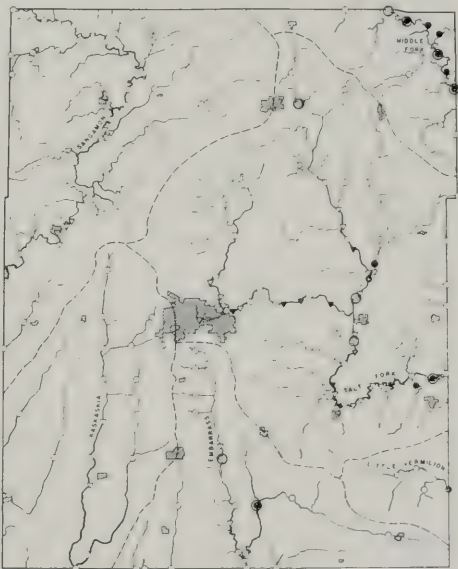


Fig. 62.—*Etheostoma blennioides*.

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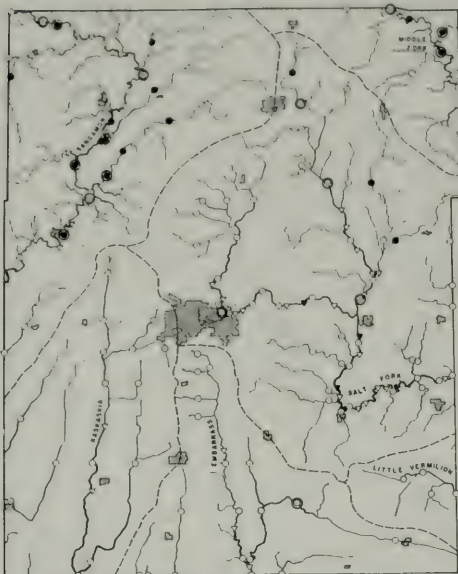


Fig. 63.—*Etheostoma flabellare*.



Fig. 64.—*Etheostoma nigrum*.

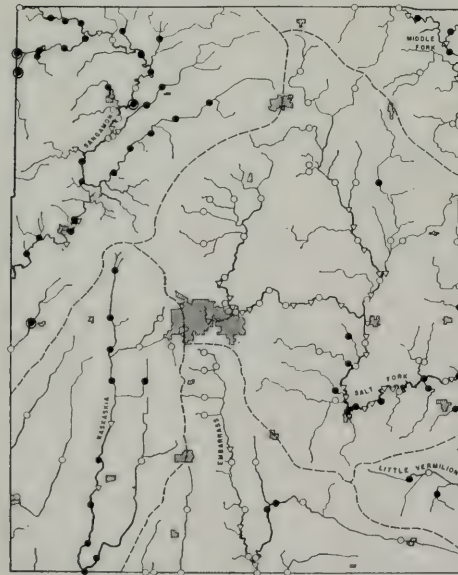


Fig. 65.—*Etheostoma spectabile*.

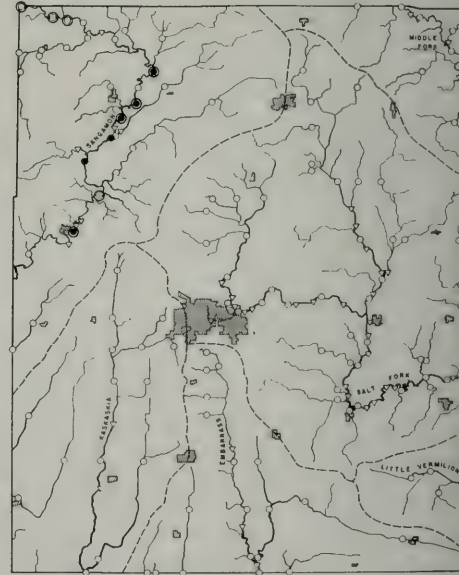
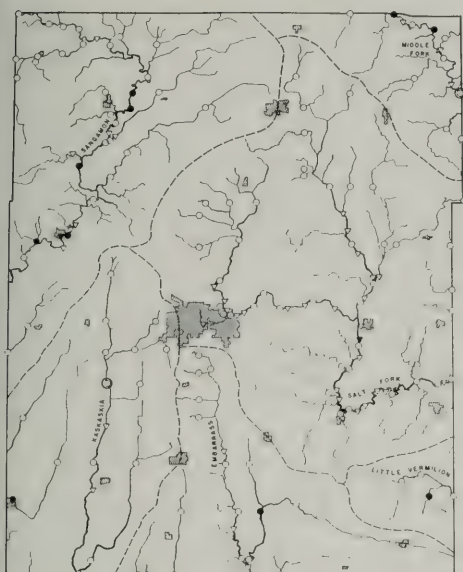
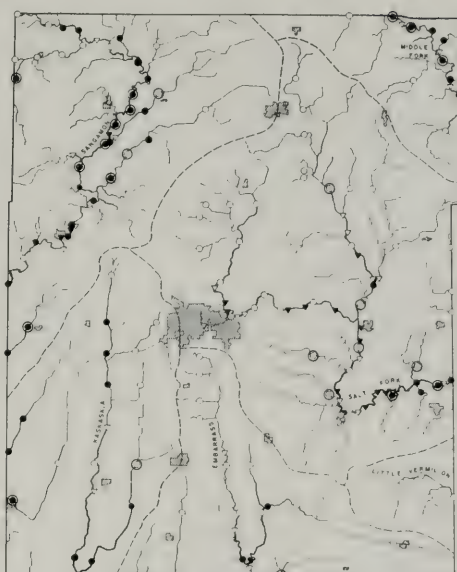
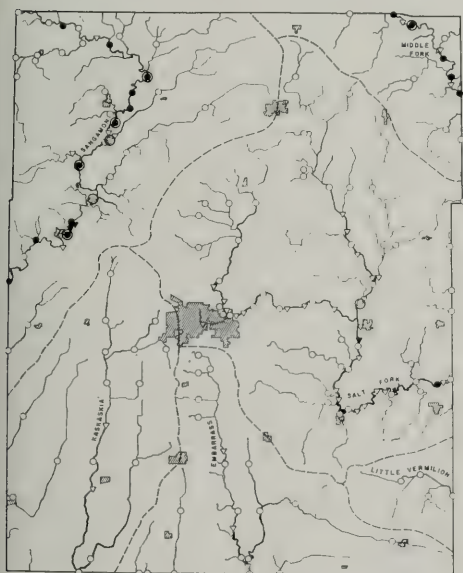
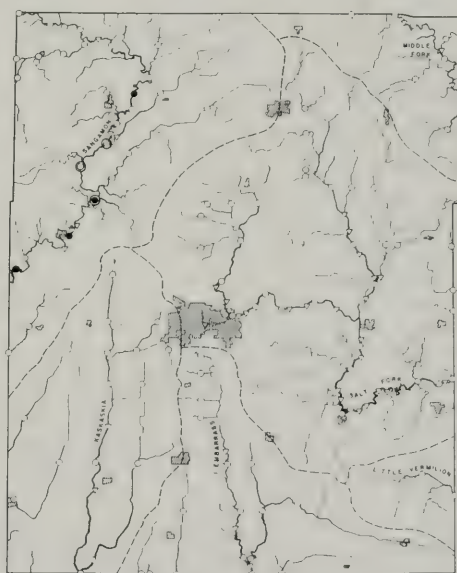


Fig. 66.—*Etheostoma zonale*.

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Fig. 67.—*Percina caprodes*.Fig. 68.—*Percina maculata*.Fig. 69.—*Percina phoxocephala*.Fig. 70.—*Aplodinotus grunniens*.

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Solid circle alone or within large circle: collecting station at which Larimore & Smith took indicated species. Most of these stations had previously been sampled by Thompson & Hunt.

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The scientific names of fishes indexed below include currently valid names, variant spellings, and synonymic names and combinations. Generic names, when they stand alone in the text, have not been indexed. Thus, *Carpiodes* spp. is not included in the index, but a text reference to any one of the species of *Carpiodes* is included. For convenience in indexing, specific and subspecific names are given equal rank. Thus, the subspecies *Notropis spilopterus hypsisomatus* is indexed as *Notropis hypsisomatus* and *hypsisomatus*, *Notropis*, and the subspecies *N. s. spilopterus* as *Notropis spilopterus* and *spilopterus*, *Notropis*. The common names used are those recommended by the Committee on Names of Fishes, American Fisheries Society. Common names used in a generic sense in the text (basses, sunfishes, catfish) have not been indexed. Common names for species have been indexed; common names for subspecies have not been indexed, as subspecies do not have officially recommended common names. Scientific names other than those of fish have not been inverted; for example, *Rorippa islandica* is listed but not *islandica*, *Rorippa*.

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ILLINOIS NATURAL HISTORY SURVEY
Bulletin

*Printed by Authority of
the State of Illinois*



A Comparative Study of
Bird Populations in Illinois,
1906-1909 and 1956-1958

RICHARD R. GRABER
JEAN W. GRABER

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
NATURAL HISTORY SURVEY DIVISION
Urbana, Illinois

ILLINOIS NATURAL HISTORY SURVEY
Bulletin

Volume 28, Article 3
October, 1963



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View of floodplain in Pope County, southern Illinois, 1907 and 1963.

Upper picture taken from cliff 1 mile east of Brownfield, June 27, 1907, by Alfred O. Gross.

Lower picture, same area as upper picture; taken May 19, 1963, by Jean W. Graber. Several of the cultivated fields of the upper picture have been filled in with forest. Tree growth conceals the railroad tracks visible in the foreground of the upper picture.



View of wooded hills in Hardin County, southern Illinois, 1907 and 1963.
 Upper picture taken from the east edge of Shetlerville, June 29, 1907, by Alfred O. Gross.
 Lower picture, same area as upper picture; taken May 19, 1963, by Richard R. Graber.
 This area shows fewer changes in a half century than most Illinois areas censused. Overgrazed pasture has replaced cultivated fields shown in the upper picture.



Landscape in Mason County, central Illinois, 1907 and 1963.

Upper picture taken one-half mile east of Poplar City, May 2, 1907, by Alfred O. Gross. Similar sandy wasteland with cacti is still found in small areas in the vicinity of the Illinois River. Such areas, if undisturbed, eventually become stabilized by grass.

Lower picture, same area as upper picture; taken May 14, 1963, by Richard R. Graber. Sand prairie develops in relatively undisturbed areas in the vicinity of the Illinois River.

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This paper is printed by authority of the State of Illinois, IRS Ch. 127, Par. 58.12. It is a contribution from the Section of Wildlife Research of the Illinois Natural History Survey. Dr. Richard R. Graber is Wildlife Associate with that section. Dr. Jean W. Graber is Research Associate in Animal Science, University of Illinois.



Landscape in Sangamon County, central Illinois, 1907 and 1962.

Upper picture taken one-fourth mile north of Buffalo Hart, June 24, 1907, by Alfred O. Gross. Cornfields have comprised the largest Illinois habitat for at least the past 100 years.

Lower picture, same area as upper picture; taken August 2, 1962, by James S. Ayars. Soybeans (left foreground) came into wide use after 1920 and by 1957 occupied about 5,000,000 acres of Illinois land.

A Comparative Study of Bird Populations in Illinois, 1906-1909 and 1956-1958

RICHARD R. GRABER

JEAN W. GRABER

ON AUGUST 29, 1906, Alfred O. Gross and Howard A. Ray, working for the Illinois State Laboratory of Natural History (a parent organization of the Illinois Natural History Survey) under the direction of Stephen A. Forbes, began a series of statewide, cross-country censuses of birds in Illinois. These censuses were continued at intervals until September, 1909, and the data collected were published in a series of papers (Forbes 1907, 1908, 1913; Forbes & Gross 1921, 1922, 1923) that provided a quantitative record of the Illinois bird populations of that period and a potential basis for evaluating the adjustment of bird populations to a changing environment. In 1956-1958, we conducted statewide censuses similar to those of the 1906-1909 survey. In this paper we present an analysis of our field data and compare these data with those from the first survey.

For suggesting and encouraging this study we are indebted to Dr. Harlow B. Mills and Dr. Thomas G. Scott of the Illinois Natural History Survey. Mr. Ronald F. Labisky of the Survey provided data on pheasant populations in a study area near Sibley, Illinois. Mr. John Ames and Mr. Herbert Brucker, both of Sibley, permitted us to establish and use special study areas on their lands. Mr. John Hill, Urbana, checked some of our calculations.

We are particularly grateful to Dr. Alfred O. Gross, *Emeritus* Professor of Biology at Bowdoin College, who presented us with all of the original field notes, journals, and photographs made on the first series of strip censuses conducted in Illinois (1906-1909) and encouraged our follow-up study. Finally, we are indebted to Mr. James S. Ayars of the Illinois Natural History Survey, who edited the manuscript.

METHODS

For an excellent review and discussion of measuring bird populations by various

methods, we refer the reader to Kendeigh (1944). Here we need a brief summary of only the Forbes-Gross method, the strip census method used in the 1906-1909 and the 1956-1958 surveys.

Forbes-Gross Strip Census

The Forbes-Gross method of censusing was described in essence by Forbes (1907:307), who stated that two observers "were sent into the field under instructions to traverse the state in various directions, traveling always in straight lines and always thirty yards apart, and noting and recording the species, numbers, and exact situation of all birds flushed by them on a strip fifty yards in width, including also those crossing this strip within one hundred yards to their front. No attention is paid by them, for this purpose, to any other birds."

Forbes likened the census operation to "a gigantic sweep-net 150 feet wide and 300 feet deep, so drawn across the country day by day as to capture every bird which comes in its way; . . ." Certain details of the method were subsequently modified in the field, but the census techniques used during most of the survey by Gross and Ray in 1906-1909 were close to those described by Forbes & Gross (1921:1-2). Our ultimate authority in determining the census technique actually used by the two observers in 1906-1909 has been the correspondence, journals, and original field notes of Dr. Alfred O. Gross.

In open-field habitats (cornfields, soybean fields, and plowed ground), the two observers stayed 30 yards apart as they censused and counted all birds within or crossing a strip 50 yards in width in line with the observers and 100 yards to the front. In more dense habitats (orchards, forest, shrub-grown areas, and hayfields), the observers maintained a distance of 20 yards between them and censused a 30-yard strip. They traveled at the rate of about 40-50 minutes per mile.



Fig. 1.—Alfred O. Gross, right, and Howard A. Ray as they appeared with winter field equipment at the time of the 1906–1909 bird censuses in Illinois.

Usually, censusing was started shortly after daybreak and continued, with interruptions, until late afternoon. No censuses were made during periods of inclement weather, that is, when there was precipitation or very strong wind. The distance traveled in each habitat was paced, tallied with a hand counter, and recorded. Other pertinent information was recorded: the date, time of day, locality, cloud condition, temperature, and number of each species of bird in each habitat. Examples of the type of field notes taken were published by Forbes & Gross (1923:448–9).

In censusing, Gross and Ray chose the general routes (Forbes & Gross 1921, frontispiece) that they would travel, that is, between certain cities or other landmarks, but the censusing was random in the sense that the habitats were not chosen arbitrarily but were censused as they were encountered along the straight-line routes.

Some of the areas censused by Gross and Ray are pictured as frontispieces and others as figs. 16, 20, 21, 29, and 30. Gross and Ray in winter field clothes and Gross on summer field trips are shown in figs. 1, 2, and 3.

In 1956–1958, we censused in most of the counties that Gross and Ray had censused, fig. 4, although we did not duplicate their routes exactly. After driving into a county, we deliberately chose a starting point in an area that seemed to represent the region. From the starting point, we walked a census strip along the perimeter of a square 1.5 to 2 miles on each side and returned ultimately to the starting point. Our rate of coverage, 45–50 minutes per mile, was comparable to that of Gross and Ray. Though we deliberately chose each census area, we did



Fig. 2.—Alfred O. Gross on rocks along the Ohio River near Elizabethtown, Illinois, June 30, 1907.

not arbitrarily select habitats, but censused all habitats as we encountered them along our straight-line routes. Thus, the habitat coverage in all our regular censusing was random.

In the summer of 1958, we did supplementary censusing in addition to our regular censusing; we deliberately chose and

nois at all seasons of the year, but because of the especially variable nature of bird populations in the migration seasons we decided to limit our censuses to the winter and summer seasons. In Illinois, spring migration of birds begins in February and extends at least through the first week in June. For some species, fall mi-



Fig. 3.—Alfred O. Gross, left, and helpers on a collecting trip near St. Joseph, Illinois, May, 1908. Gross and fellow students were studying distribution of various species of animals in Illinois. This particular field work was not part of the bird censuses of 1906, 1907, and 1909.

censused additional acreage of certain habitats of limited area, such as marsh and orchard. We did this because we had encountered only a small acreage of these habitats along our regular census routes. Data from the supplementary censusing are included in tables with data from the regular censusing.

In northern Illinois, we made censuses in the two northernmost tiers of counties except Cook County. In central Illinois, we conducted censuses through Vermilion, Champaign, Ford, Piatt, De Witt, Macon, Logan, Mason, Fulton, McDonough, and Hancock counties. In southern Illinois, we censused through Wabash, Edwards, Wayne, White, Gallatin, Hardin, Pope, Massac, Johnson, Pulaski, Alexander, Union, Jackson, Randolph, Perry, Jefferson, and Franklin counties.

The original studies by Forbes & Gross included data on bird populations in Illi-

gration is under way by mid-July, and the migration lasts until December. Therefore, we conducted most of our summer censuses between early June and mid-July and our winter censuses between early December and March 1. Having access to Dr. Gross' original field notes, we were able to recalculate the 1906–1909 population densities for precisely the seasonal periods used in our censuses, thus insuring that the two sets of data were seasonally comparable. Because of the seasonal limitations and our recalculations mentioned above, our data for the Gross and Ray censuses do not correspond with data published by Forbes & Gross.

Population data in this paper represent summer and winter censuses of the two surveys. The summer censuses were made during the following periods: in northern Illinois—June 30, July 1–3, 5–8, 1909; June 25–29, July 1–2, 1957; and June

30–July 4, July 10–12, 14–15, 1958; in central Illinois—May 22–23, 27–29, 31, July 9–13, 15, 1907; June 22–26, 28–29, 1909; June 18–19, 21–24, July 8, 10, 12, 1957; and June 15, 17, 23–28, July 10, 1958; in southern Illinois—June 4–8, 10–14, 17–21, 25–29, July 1, 1907; June

13, 17–18, 1906; January 21–25, 27, 29–30, February 1, 1907; December 14, 17, 1956; February 4–8, 1957; February 5–6, 12–14, 24–26, 1958; in southern Illinois—February 6–8, 9, 11–14, 18–21, 1907; December 27–28, 1956; January 8–13, 1957; and February 7–11, 1958.

Forbes & Gross (1923:436) stated that the strip census method used in their studies limited them "to birds of more or less open country." Although reduced visibility in woodlands and dense shrub habitat undoubtedly affected the accuracy of the method, data for such habitats were gathered both in the earlier field work and in our own. However, in considering the value of the method, we were concerned primarily with open-field areas. In defining habitats, we placed primary emphasis on the nature of the land cover, not on the land use. Thus, we classified a stand of alfalfa as a kind of hayfield even if it had been grazed.

Ideally, all habitats censused should be represented by comparable large-size samples, but in random strip censuses, such as were used in the recent and earlier studies, the observers covered different habitats approximately in proportion to the total acreage of each habitat in the areas censused. For certain habitats (such croplands as corn and small grain, for example) areas of several hundred acres were represented, while for some other habitats (for example, vegetable crops) only a few acres were represented. The data for habitats represented by only a few acres are probably not very significant; thus, there is a certain amount of waste in random strip censusing.

In this paper, we have summarized virtually all the field data that were collected in the summer and winter seasons in both the 1906–1909 period and the 1956–1959 period regardless of sample size, but the question of what constitutes an adequate census area deserves further consideration in order to help the reader evaluate the data.

The size of an adequate census area probably varies from habitat to habitat and season to season. In many habitats, open-field habitats especially, bird populations are much more variable in winter than in summer, and winter census areas should presumably be larger than summer

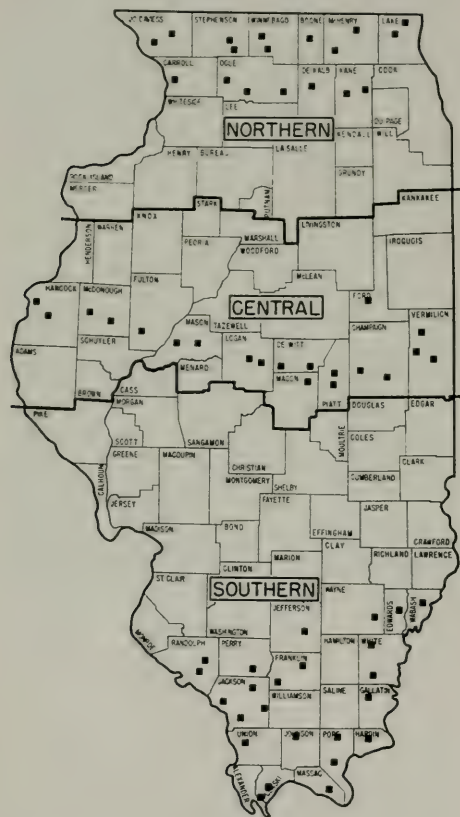


Fig. 4.—Areas (indicated by black squares) in which the strip census method of estimating bird populations was used in 1956, 1957, 1958, and 1959. In most areas, censuses were made in both summer and winter, in a few areas in only one of these seasons. The boundaries between the northern, central, and southern zones discussed in this paper are shown by heavy lines.

8–11, 14–17, July 13–15, 1909; June 11–17, July 8–10, 1957; and June 13–14, 18–21, July 8–9, 1958.

The winter censuses were made during the following periods: in northern Illinois—December 3, 6–8, 10, 1906; January 2–5, 8–11, 14–17, 1907; December 4–6, 1956; January 22–23, 1957; February 27, 1958; in central Illinois—December 11,

areas. To obtain information on the relationship between the size of the census area in open fields and the measures of the bird population in such fields, we examined data on open-field bird populations from 427 summer strip counts in

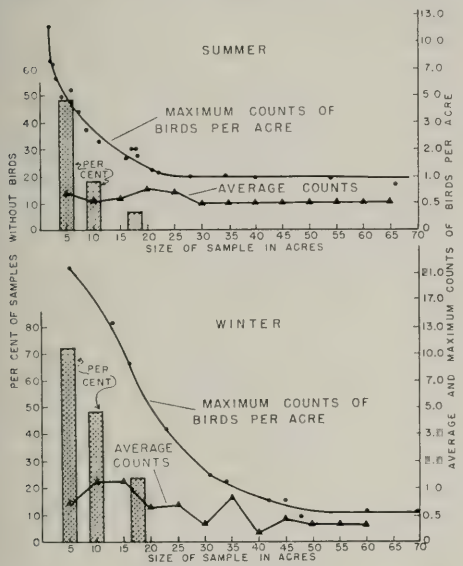


Fig. 5.—Bird population data for census areas (samples) of different sizes: (1) the per cent of the areas (samples) on which no birds were found, (2) the average numbers (average counts) of birds per acre, and (3) the maximum numbers (maximum counts) of birds per acre.

areas ranging in size from 0.3 acre to 80 acres and from 203 winter strip counts in areas ranging in size from 0.2 acre to 74 acres. Three measures of bird populations in these sample areas are presented in fig. 5. The three measures were (1) the per cent of areas of different sizes void of birds, (2) the maximum counts of birds per acre in areas of different sizes, and (3) the average count of birds per acre for sample areas in each size class.

In all strip census areas of 5 acres or less, about 49 per cent were void of birds in summer and 72 per cent in winter, fig. 5. For areas of 6–10 acres, the percentages were 19 in summer and 49 in winter, and, for areas of 11–20 acres, 7 in summer and 23 in winter. In summer, all census samples of 19 acres or more contained at least 1 bird. In winter, 17 per cent of the areas of 21–30 acres had no birds, but all

areas of 28 acres or more contained at least 1 bird.

The curves representing the maximum counts of birds per acre in areas of different sizes, fig. 5, showed greater extremes of bird populations in winter than in summer and consequently indicated the requirement of larger sample areas in winter. Maximum counts in plots of 5 acres or less were about 12 birds per acre in summer and 22 per acre in winter. As the size of the census plot was increased, the curve of maximum counts fell steeply (more steeply in summer than in winter), tended to level out, and attained a nearly constant level at about 25 acres in summer and 50 acres in winter.

The average counts of birds per acre in areas of different sizes showed the significance of the size of the census area. In summer samples, the mean number of birds per acre fluctuated noticeably in samples under 30 acres but was relatively constant in larger areas. In winter samples, the mean fluctuated greatly in samples under 50 acres but tended to level out for samples of larger size.

These data suggest that, when the strip census method is used, the minimum size of census areas of open-field habitat should be not less than 30 acres in summer and not less than 50 acres in winter.

In discussing results of strip censuses, Forbes (1907:308–9, 1913:374–5) used the terms *most important*, *most abundant*, and *more abundant* to designate those species of birds that together made up 85 per cent of a censused bird population, as, for example, the birds of a given habitat in summer. This percentage was selected arbitrarily. Because 85 per cent provides a good sample of the avifauna, we used this figure throughout the study in determining the species designated as *common* in the various habitats discussed. (In determining the *common* birds in the statewide population, we used 70 per cent, table 56; the number of species that together made up 85 per cent of the state population was too great to be included conveniently in a table.)

Our data on Illinois acreages of the various habitats, fig. 6, have been derived from one or more of four principal sources: (1) published records of the U. S. Bureau of the Census (1913, 1961), (2)

published records of the Illinois Cooperative Crop Reporting Service (Ewing 1959), (3) the published wetlands survey of the U. S. Fish and Wildlife Service (Shaw & Fredine 1956), and (4) published records of the University of Illinois Agricultural Experiment Station (King & Winters 1952). These sources were supplemented by unpublished records of the 1906–1909 and the 1956–1958 bird censuses.

In discussing estimates of Illinois bird populations, we have referred to northern, central, and southern zones of the state, fig. 4. For convenience, we based these zones on agricultural districts defined by the Illinois Cooperative Crop Reporting Service (Ewing 1959, map).

In this study, the treatment of two such similar species as the eastern and the western meadowlarks, as well as the black-capped and the Carolina chickadees, offers a problem. Because in most instances we could not make specific determinations in these groups, we have usually lumped the data for the two species under one heading, for example, meadowlark (species?) or chickadee (species?).

The basic quantitative data for this study are presented in two types of tables, the first with emphasis on statistics (example: table 4), intended only to give the reader some impression of the inherent variability in the population data presented, and the second with emphasis on avifauna (example: table 5), intended to

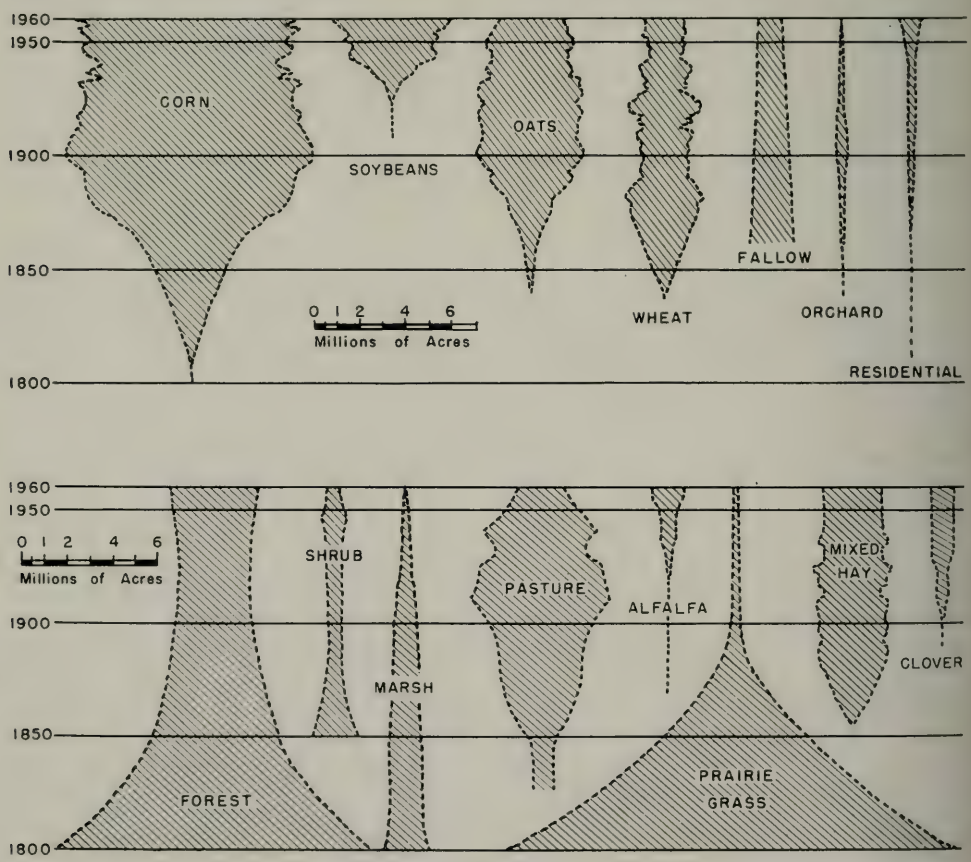


Fig. 6.—Acreage of various bird habitats in Illinois from about 1800 through the years of the bird surveys reported here. Acreage data are principally from four sources: published records of the United States Bureau of the Census, published records of the Illinois Cooperative Crop Reporting Service (Ewing 1959), published wetlands survey of the U. S. Fish and Wildlife Service (Shaw & Fredine 1956), and published records of the University of Illinois Agricultural Experiment Station (King & Winters 1952).

provide data on the species of birds found in each habitat. Each table of the second type is arranged with the most numerous or the most frequently encountered species at the head of the list. Species of equal frequency are listed in phylogenetic sequence according to the American Ornithologists' Union (1957). Unidentified birds and birds identified only to genus, except those in *Sturnella* and *Parus*, are listed at the end of each of these tables. A few of these tables include species that appear to be out of habitat (for example, the Canada goose listed in table 54, the table for winter forests). The census method required that birds should be counted if they were in or over the census strips in front of the observers. In the example mentioned, a small flock of Canada geese crossed the census strip above some woodlands we were censusing. Thus, the ecological picture presented in this and a few other tables is somewhat distorted.

In the summer avifaunal tables for certain habitats, we have designated some species of birds as being breeding species in those habitats. This designation means that the species were found nesting in the habitats either during the 1907-1909 or the 1957-1958 surveys.

In this publication, we have adopted the common names of birds as presented by the American Ornithologists' Union (1957). A list of common and scientific names of all species encountered in the censuses appears in table 55.

Evaluation of Strip Census

The strip census estimate of a bird population presumably has some relationship to the true population. A relatively constant relationship is all that we require of a census technique that we use to make comparisons between populations in different habitats (or different time periods). The question remains as to how closely the strip census estimate approximates the true population of birds in a given habitat. Cooke (1915:2) felt that the strip census as reported by Forbes (1908) was so radically different from the breeding-bird census that figures from the two censuses were not comparable.

In order to determine how closely the strip census method reflected the true bird population, we ran both strip censuses and

breeding-bird censuses on special study areas and compared the results. The breeding-bird census technique (Stone 1950:185-6) has been widely accepted as a reasonably accurate estimate of the true bird population of an area.

Our comparison of the two types of census was conducted in June, 1959, on two study plots, each a 40-acre hayfield, located 1.5 miles apart near Sibley, Illinois. One field belonged to John Ames, the other to Herbert Brucker. The study plots were measured and staked off into squares of 1.6 acres each. In these areas, we made counts of singing males in the early morning (0600 to 0800 Central Standard Time) and located as many nests as possible. During the month, we determined as closely as possible the number of birds breeding on each of the 40-acre tracts. We conducted breeding-bird counts usually every other day and on alternate days ran strip censuses across the study areas. In making the strip censuses in these fields, we followed the procedure used in censusing hayfields on our regular censuses.

We chose hayfields for study because they support a fairly high bird population and a varied nesting fauna, and we were interested in qualitative as well as quantitative comparison of data collected by the two methods.

The two 40-acre fields differed in avifaunal characteristics and other aspects. The Ames field was rolling and contained a higher percentage in sweet clover, while the Brucker field was flat and contained a higher percentage in red clover. The two fields harbored the same principal species of birds, though in different proportions, fig. 7. Our breeding-bird censuses indicated that the populations of birds in the Ames (area A) and the Brucker (area B) fields consisted of bobolinks, 28 and 24 per cent, respectively, of the total breeding-bird population; dickcissels, 25 and 40 per cent; redwinged blackbirds, 21 and 10 per cent; grasshopper sparrows, 16 and 18 per cent; meadowlarks (*Sturnella* spp.), 8 per cent in each area; and Henslow's sparrows, 2 and 0 per cent. Our strip censuses showed that the populations of the two areas, A and B, consisted of bobolinks, 39 and 15 per cent, respectively; dickcissels, 17 and 45 per cent; redwinged

blackbirds, 16 and 10 per cent; grasshopper sparrows, 16 and 22 per cent; meadowlarks, 11 and 7 per cent; and Henslow's sparrows, 2 and 0 per cent. Though the strip censuses did not show the population characteristics precisely, they clearly reflected the differences between the two fields and provided a reasonably accurate qualitative picture of the populations.

Quantitatively, populations of the two fields differed markedly, as shown by both the breeding-bird and the strip censuses.

The population density of passerine birds, as indicated by the breeding-bird censuses, was 4.6 nesting birds per acre for area A and 2.6 for area B. The density, as indicated by the strip censuses, was 4.5 nesting birds per acre for area A and 2.9 for area B.

The closeness of the two sets of figures is surprising because of the difference in potential between a breeding-bird census and a strip census. In a breeding-bird census, in which a high percentage of the nests in an area are located, the researcher

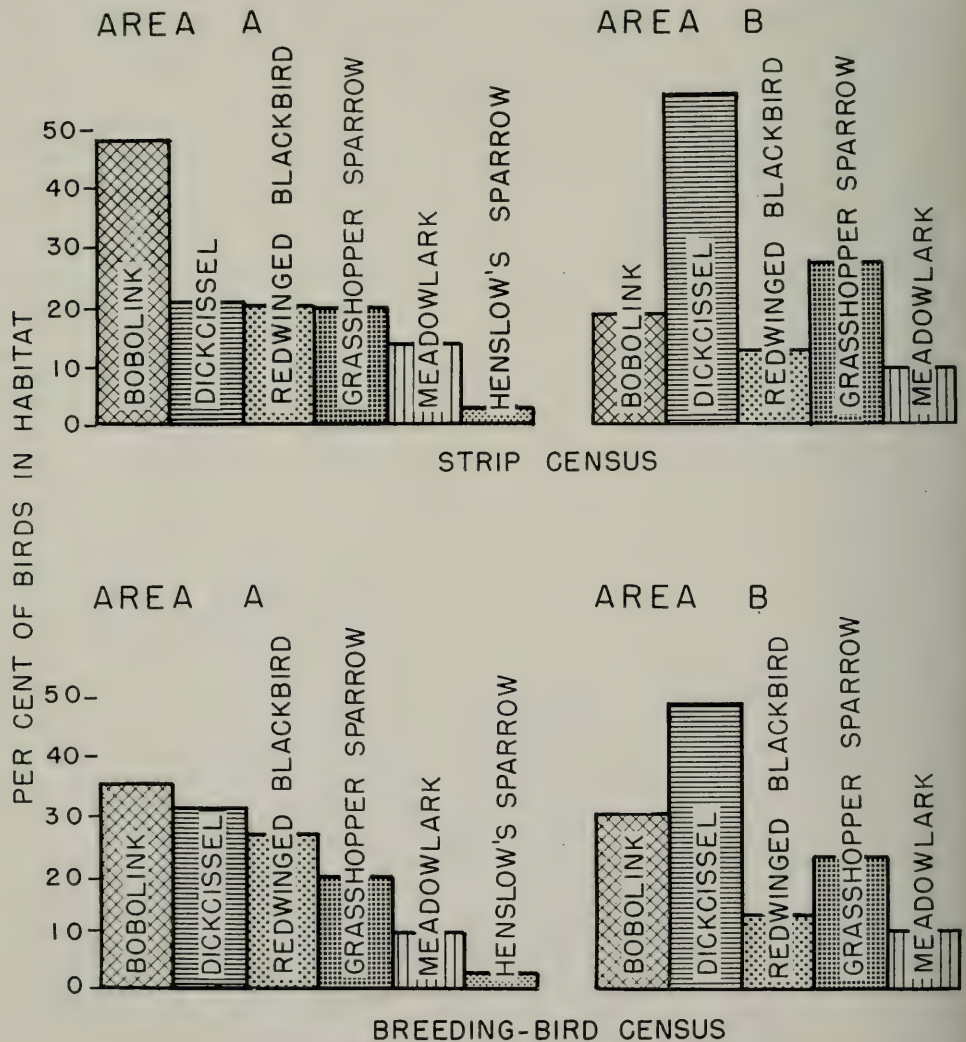


Fig. 7.—Species composition of the nesting avifauna (excluding game birds) of two 40-acre hayfields (areas A and B) as determined by two types of census, the breeding bird census and the strip census. The histograms show the per cent each species comprised of all birds counted in each habitat.

obtains a close approximation of the true population density, including both males and females of each species. In the strip

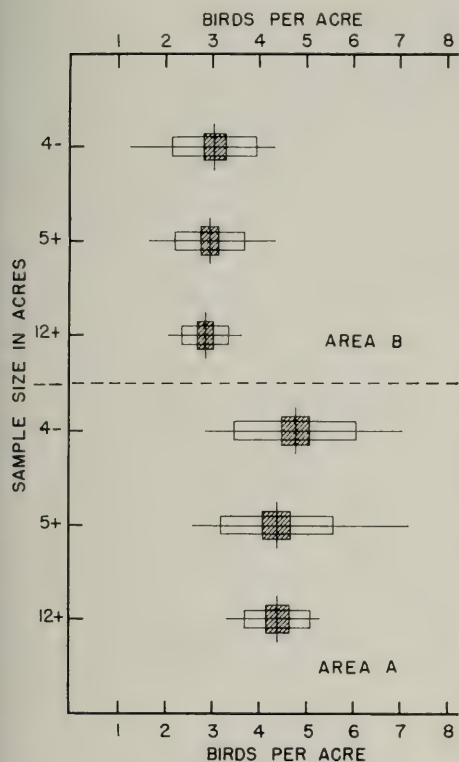


Fig. 8.—Populations of nongame birds in census areas of different sizes. The populations were estimated by strip censusing in two hayfields, areas A and B. Strip census areas (samples) were categorized by size (4 acres or less, 5 acres to 9 acres inclusive, 12 acres or more); each sample area represented 14 censuses conducted between June 4 and 21, 1959 (0600–1200 CST). The horizontal line through each open box represents the range of variation in the measure of the bird population; the vertical line represents the mean population based on 14 censuses. Each open box represents one standard deviation each side of the mean, and each shaded box represents one standard error each side of the mean.

census, on the other hand, some females (especially incubating females) are probably overlooked, and, consequently, we might suppose the density indicated by a strip census to be less than the density indicated by a breeding-bird census. The figures on density presented above do not bear out this supposition. To some extent the similarity in density figures is brought

about by the behavior of the breeding males. There is a tendency for males of many species to approach the census strip and enter or cross it. This behavior may represent curiosity or aggressiveness toward an intruder; it has the effect of exaggerating the count of males per unit of area. By chance, this mechanism appears to compensate for the low count of females during the incubation season.

Variations in the strip census estimates of bird populations on the two special study areas are shown in fig. 8. The range of density values tended to decrease in strip census data as the size of the area censused increased, fig. 8. When the area censused was 4 acres or less, density values for the Ames area ranged from 2.9 to 7.1 birds per acre on different census trips, while the values for areas of 12 acres or more ranged from 3.3 to 5.3. For the Brucker area, comparable values were 1.3 to 4.4 birds per acre (4 acres or less) and 2.1 to 3.7 birds per acre (12 acres or more).

The data for population densities presented above apply to nesting passerine birds only. Besides these passerines, there was a high population of pheasants in the Sibley area in which the Ames and Brucker fields were located. Ronald F. Labisky of the Illinois Natural History Survey, who has made intensive studies of the pheasant population in the Sibley area, reported that during the 1959 breeding season about 1.3 pheasant nests were established per acre of hayfield. Neither the breeding-bird census nor the strip census indicated a density of this magnitude for pheasants. The breeding-bird census indicated a pheasant population of 0.07 nest per acre on area A and 0.12 per acre on area B. The strip census indicated a population of 0.05 pheasant per acre on area A and 0.02 per acre on area B.

Obviously, the strip census method is much less reliable for estimating pheasant populations than for estimating populations of the more conspicuous passerines.

Cooke (1915:2) pointed out that the number of birds per square mile in southern Illinois in June, 1907, as reported by Forbes (1908), was less than half the average for the national (breeding-bird) census; Forbes based his figures on strip censuses. The population data in our paper

are of value primarily for comparisons within this study, and the reader should recognize the specialized nature of the data.

The greater variation of bird populations in winter than in summer has already been mentioned. It is difficult to determine to what degree the strip census estimates reflect the true winter population. In winter, birds are not so evenly distributed as in summer and they are less restricted to definite territories. These conditions decrease the accuracy of censusing, regardless of the method used. The great variation in population data from

four strip censuses in each of two areas in winter is shown in tables 1 and 2. Total population densities as indicated by the strip censuses varied from 10 to 107 birds per 100 acres in the cornfield and from 35 to 215 birds per 100 acres in the woodland.

Only 1 of the 5 species recorded in the cornfield habitat was found on all four census trips, and only 2 species were found on at least three census trips. In the woodland habitat, only 2 of 16 species of birds were found on all four census trips, only 4 species on at least three censuses, and 12 species on at least two censuses. Ad-

Table 1.—Bird populations of a central Illinois cornfield in the winter of 1958–59 as determined by 40-acre strip censuses on four dates.

SPECIES	BIRDS PER 100 ACRES			
	December 18	December 19	December 30	January 13
Lapland longspur.....	5	89	5	12
Mourning dove.....	---	18	3	71
Horned lark.....	---	---	---	12
Ring-necked pheasant.....	5	---	---	---
Tree sparrow.....	---	---	3	---
<i>Total birds per 100 acres.....</i>	<i>10</i>	<i>107</i>	<i>11</i>	<i>95</i>
Number of species.....	2	2	3	3

Table 2.—Bird populations of a central Illinois woodland in the winter of 1958–59 as determined by 20-acre strip censuses on four dates.

SPECIES	BIRDS PER 100 ACRES			
	December 5	December 19	December 29	January 13
Downy woodpecker.....	30	5	15	---
Red-bellied woodpecker.....	15	15	5	5
Tufted titmouse.....	37	10	---	---
Common crow.....	---	---	30	5
Chickadee (species?).....	30	5	---	---
Brown creeper.....	22	5	5	---
Yellow-shafted flicker.....	22	---	5	---
Slate-colored junco.....	22	---	---	5
Blue jay.....	---	5	20	---
Hairy woodpecker.....	---	---	15	10
Cardinal.....	7	5	5	5
Eastern bluebird.....	15	---	---	---
White-breasted nuthatch.....	---	5	5	---
Golden-crowned kinglet.....	---	10	---	---
Tree sparrow.....	---	---	10	---
Carolina wren.....	---	---	---	5
<i>Dendrocopos</i> (species?).....	---	---	10	---
Unidentified bird.....	15	---	5	---
<i>Total birds per 100 acres.....</i>	<i>215</i>	<i>65</i>	<i>130</i>	<i>35</i>
Number of species.....	9	9	10	5

mittedly, the sample census areas, 40 acres for open field and 20 acres for woods, were small for winter censusing.

The high variability shown in our winter census data appeared to be more a characteristic of winter bird populations than a defect of the census method. Regardless of its source, high variability makes interpretation of winter data more difficult and probably less reliable than interpretation of summer data.

That bird populations of an area may fluctuate greatly from year to year is well recognized. Data presented by Kendeigh (1944:93-4) showed that the number of breeding birds in a 55-acre forest in east central Illinois fluctuated (increased or decreased) from one year to the next an average of 23 per cent (average of differences between consecutive spring populations) in 11 years. The minimum difference (increase or decrease) between populations in consecutive years was 5 per cent and the maximum 44 per cent. Fluctuations for particular species were even greater; the red-eyed vireo population changed from 0 in 1940 to 13 pairs in 1941, and the number of house wrens increased from 10 pairs in 1940 to 20 pairs in 1941. Year-to-year fluctuations in winter populations were even greater than in spring populations, averaging 46 per cent (average of differences between consecutive winter populations) for 14 years. The minimum difference (increase or decrease) between consecutive winter populations was 4 per cent and the maximum 133 per cent.

Bird populations in open-field habitats are probably as variable as in forests. Data presented by Mrs. H. A. Baker (1955-1961) indicated that the number of breeding birds on 16 acres of hayfield and pastureland in central Indiana fluctuated from year to year, over a 7-year period, by 23 per cent (average of percentage differences between consecutive summer populations). This is the year-to-year fluctuation percentage shown in Kendeigh's summer forest populations.

Year-to-year fluctuations greatly complicate interpretation of our census data, representing as they do only 4 years in 50. Our conclusions on the subject of population changes rely to some extent on other sources of history; they must be considered

tentative and always open to reinterpretation.

WEATHER PATTERNS OF CENSUS YEARS

The weather conditions that preceded and accompanied the two census periods are worthy of consideration, even though the effect of weather on bird populations is difficult to evaluate. Most of the birds that breed in Illinois spend a large part of the year well to the south of this state, and most of the species that remain through the year are adapted to survive the rigors of Illinois winters.

Available data indicate that adult passerine birds have a strong tendency to home to the same nesting area year after year. This behavior probably helps to reduce population fluctuations in a given geographic area. Population stability depends, of course, partly on survival of adult birds. Some species, such as the eastern bluebird, are known to suffer large population losses during severe winters.

In trying to evaluate the possible effect of weather on the bird populations of Illinois, we should consider both the general weather patterns and the extreme conditions that may have affected bird survival.

No prolonged period of adverse weather (excessive precipitation or extremes of temperature) occurred between 1899 and January, 1904. But unusually low temperatures in January, February, and April, 1904, may have had an adverse effect on bird populations, particularly of early-nesting species. Record-breaking cold occurred in February, 1905, but it did not endure for long and probably had little effect on bird populations. Precipitation was not unusual in any of these years. It seems doubtful if weather factors (even the cool spring of 1904) in the years leading up to the 1906-1909 surveys had any widespread effect on the bird populations censused in these surveys. Temperature and precipitation patterns in the survey years themselves, figs. 9 and 10, were probably more important.

The winter of 1906-07 was comparatively warm and moderately rainy, but the following spring and summer months were extremely cold, the coldest at least since 1878, and the cold, especially that in April and May, could have had a notable effect

on the state bird population. The census data indicate that the 1907 breeding population of birds in Illinois was conspicuously lower than the population of 1909, a normal year in terms of weather. The fact that many species had low populations

in 1907 will be mentioned repeatedly in the following text, and the reader should bear in mind that the adverse spring weather of 1907 may have played a role in this depression. The winter of 1908-09 was mild, the following spring and sum-

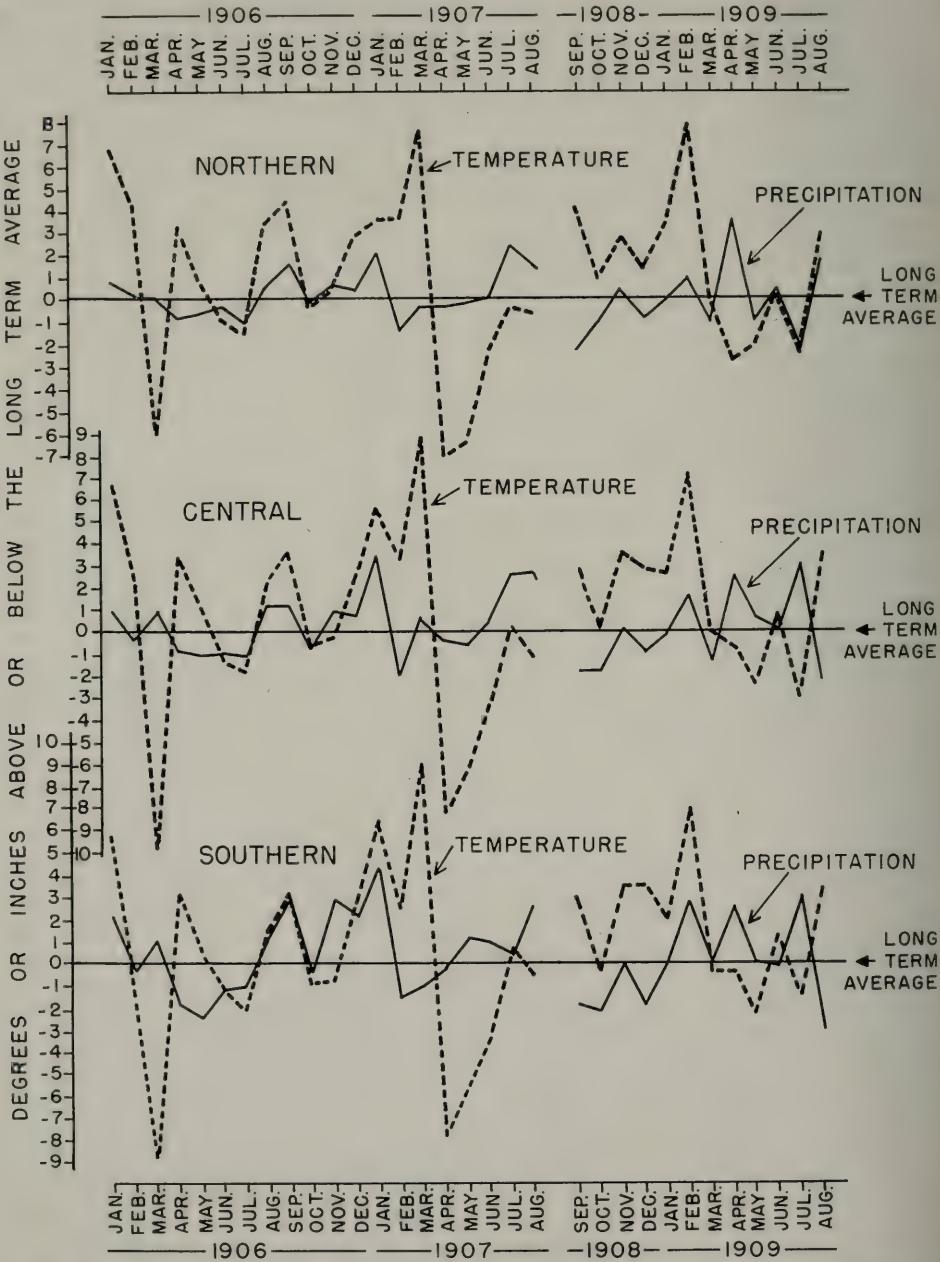


Fig. 9.—Temperature and precipitation deviations from the long-term averages in the northern, central, and southern zones of Illinois during and immediately preceding the years of the bird surveys of 1906-1909.

mer were near normal in terms of weather, and the 1909 level of the breeding population of birds in Illinois was well above the 1907 level. Bird populations are

usually quick to recover from a depression.

Weather in the years from 1952 to the beginning of the second bird survey (1956) was marked by drought, but it

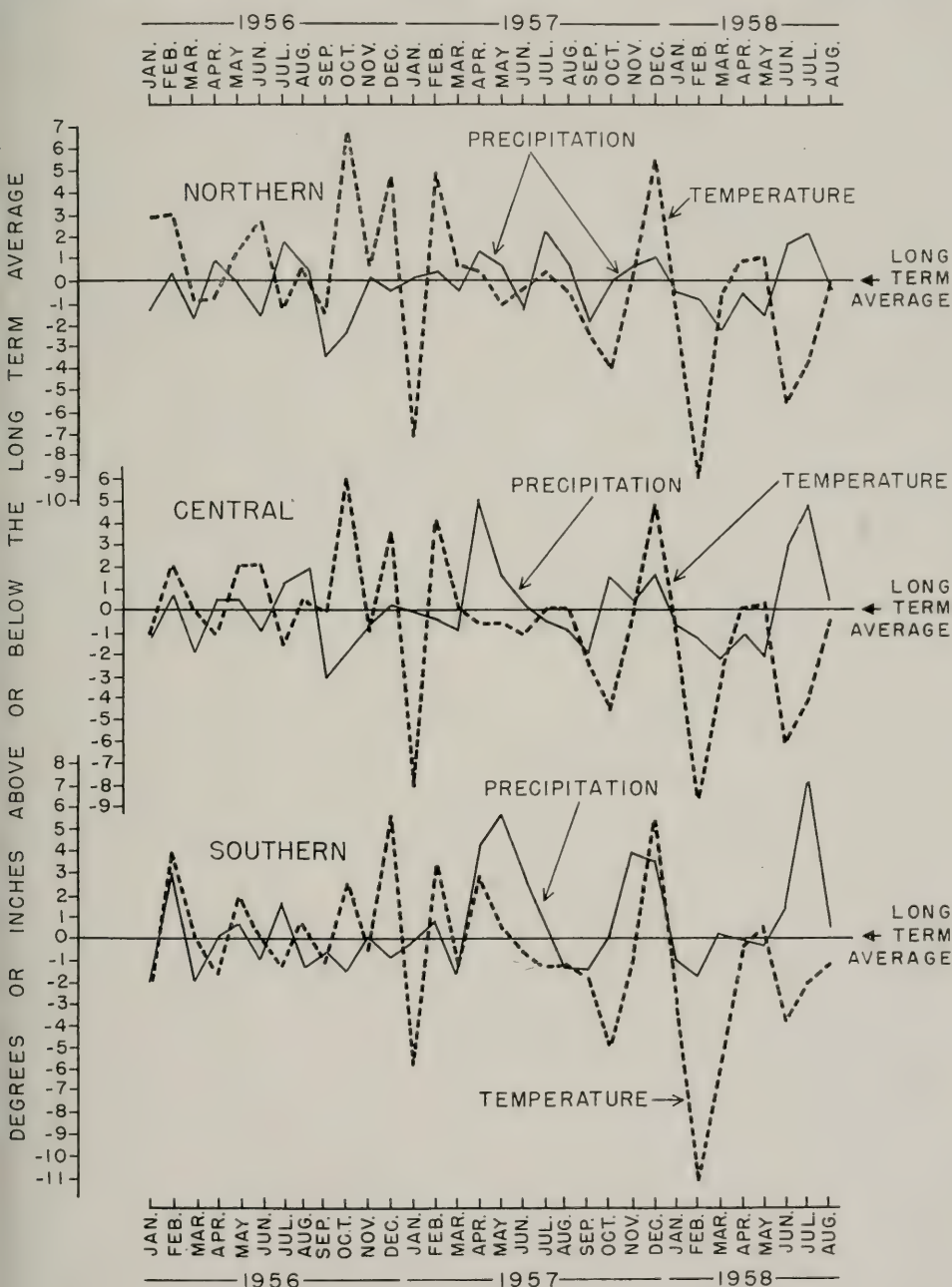


Fig. 10.—Temperature and precipitation deviations from the long-term averages in the northern, central, and southern zones of Illinois during and immediately preceding the years of the bird surveys of 1956–1958.

was not unusual otherwise. We do not know what effect low precipitation had on bird populations, but by 1956 the precipitation level was coming back to normal, and we judge that the dryness of the earlier years probably had little effect on the bird populations surveyed.

The census years of 1956–1958 showed a variable weather picture, fig. 10, with temperature and precipitation fluctuating to about the same degree as in 1906–1909. The winter of 1956–57 in Illinois was relatively warm (except in January) and precipitation was normal; the following spring and summer were about normal in temperature and normal or above normal in precipitation. No known weather conditions in this year would have had any special effect on bird populations in the state. The start of the winter of 1957–58 was mild, and precipitation continued to be normal, but February and March were very cold. The cold may have depressed populations of at least a few species of birds. The late part of the following spring was warm, but the summer was cool and wet. The summer conditions may have had an adverse effect on production of young birds, but the adult population,

with which we were primarily concerned, was probably not greatly affected. Our census data show that the state population of nesting birds was about the same in 1958 as in 1957 and tend to support the view that the early spring cold in 1958 had no general depressing effect on the state bird population.

The years 1909, 1957, and 1958 in Illinois were probably similar to each other in terms of weather and its effect on bird populations. The 1907 bird population was depressed, and weather probably had a bearing on this depression.

BIRD POPULATIONS IN
SUMMER HABITATS

Between the dates of May 22 and July 15, 14,447 acres were covered by strip censuses, 7,662 acres in 1907–1909 and 6,785 in 1957–1958. Acreages of the different habitats censused in the two study periods combined ranged from 4,003 acres of corn to 1 acre of sugar cane. Because it is pointless to discuss bird populations in habitats represented by only small acreages, we have disregarded habitats represented by less than 50 acres. In table 3 are listed the summer habitats discussed in

Table 3.—Acreages of habitats covered by summer strip censuses in the three zones of Illinois, 1907–1909 and 1957–1958.

TYPE OF HABITAT	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE		TOTAL
	1907– 1909	1957– 1958	1907– 1909	1957– 1958	1907– 1909	1957– 1958	
Corn (all types)	353	616	1,159	629	987	259	4,003
Pasture	193	279	442	171	882	120	2,087
Oats	241	166	596	123	183	10	1,319
Mixed hay (including mowed)	175	212	125	89	534	77	1,212
Forest (all types)	2	177	16	214	60	340	809
Soybeans	—	167	—	489	—	121	777
Wheat (including shocked)	6	16	169	63	381	138	773
Fallow fields	24	48	24	37	319	230	682
Red clover	11	110	46	90	104	85	446
Residential areas	11	160	8	75	35	98	387
Plowed ground	3	20	11	28	134	139	335
All shrub and hedge	4	47	3	70	56	151	331
Ungrazed grass	15	96	1	49	41	88	290
Alfalfa	2	138	7	41	—	49	237
Orchard	—	36	6	7	45	78	172
Marsh	19	90	3	1	26	16	155
Garden crops	40	5	20	1	45	—	111
Small grain stubble	—	3	1	13	1	76	94
Sweet clover	—	26	—	25	1	5	57
Barley and rye	18	—	2	—	14	—	34
Total	1,117	2,412	2,639	2,215	3,848	2,080	14,311

this paper and the acreages covered by the strip censuses.

Population data in both tables and text refer to supposedly adult birds. Juvenile birds were counted during the censuses, but, in order to eliminate a source of variability, we did not include obviously juvenile birds in population calculations.

Cornfields (Summer)

In terms of acreage, corn is the principal crop of Illinois. The cornfield habitat comprised almost 28 per cent (4,003 acres) of the land censused in the summers of 1907-1909 and 1957-1958, table 3. From the data sources mentioned previously, we calculated that corn acreage declined from about 10,400,000 acres in 1907 to 8,400,000 in 1957. Practices in corn culture have changed, but the characteristics of cornfields at the time of year the censuses were made have remained the same, fig. 11. At this season, the young plants in widely spaced rows (about 40 inches apart) usually varied in height from 3 or 4 inches to 2 feet, though some fields with plants over 3 feet in height were censused. The dominating feature of the cornfield habitat in early summer is bare ground.

Quantitatively, corn is poor bird habitat, figs. 22-24. Mean numbers of birds

per acre in corn for all census years in the three zones of the state in summers varied from 0.3 to 0.9, and the extreme variation for consecutive census years was 0.7 to 0.3 in 1957 and 1958, table 4. Population densities were consistently higher in the northern zone than in other parts of the state. Also, they tended to be higher in the later than in the early census years, but the extreme annual variations preclude any precise conclusion on changes, between 1906 and 1958, in density of bird populations in cornfields of the state. Though there was no conclusive evidence of a general quantitative change in total bird population, the composition of the avifauna had altered.

At least 60 species of birds were recorded in summer cornfields in the two study periods combined; this figure probably reflects the large acreage covered more than it does the quality of the habitat. The complete list of species, with population figures for each, is presented in table 5. Only 5 of the species (horned lark, grackle, house sparrow, mourning dove, and redwinged blackbird) were recorded in this habitat in all years and all zones.

The number of common species (those comprising 85 per cent of the population) in summer cornfields was higher in 1907

Table 4.—Statistical data on summer bird populations in Illinois cornfields as determined by strip censuses in the three zones. Data are (1) from all cornfields censused and (2) from sample areas (each 10 acres or more) in these fields.

ZONE AND YEAR	ALL CORNFIELDS CENSUSED		SAMPLE AREAS					
	Acres	Birds Per Acre	Number	Birds Per Acre				
				Range	Mean	Standard Deviation	Standard Error	Mean ± 2 S.E.
Northern								
1909.....	351	0.6	8	0.3-0.8	0.6	0.2	0.1	0.4-0.8
1957.....	317	0.9	11	0.2-1.5	0.8	0.4	0.1	0.6-1.0
1958.....	299	0.9	6	0.0-2.4	1.0	...	....	....
Central								
1907.....	668	0.3	11	0.1-1.0	0.3	0.2	0.1	0.1-0.5
1909.....	488	0.5	7	0.2-0.7	0.4	....	....	....
1957.....	328	0.7	13	0.2-1.5	0.7	0.4	0.1	0.5-0.9
1958.....	290	0.3	5	0.0-0.4	0.2	...	...	....
Southern								
1907.....	550	0.4	19	0.0-0.8	0.4	0.2	0.1	0.2-0.6
1909.....	433	0.7	11	0.3-1.5	0.7	0.3	0.1	0.5-0.9
1957.....	103	0.5	1	.....	0.3	....	....	....
1958.....	156	0.7	10	0.0-1.7	0.7	0.5	0.2	0.3-1.1

Table 5.—Summer avifauna in Illinois cornfields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate number of acres censused; + indicates less than 1 bird per 100 acres; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909 (351)	1957 (317)	1958 (299)	1907 (668)	1909 (488)	1957 (328)	1958 (290)	1907 (550)	1909 (433)	1957 (103)	1958 (156)
*Horned lark	10	27	39	7	5	43	20	2	+	8	3
Common grackle	13	6	13	5	11	7	3	5	7	5	4
House sparrow	8	8	1	4	6	8	2	1	6	2	6
Mourning dove	2	3	5	1	5	+	1	7	6	1	6
Redwinged blackbird	3	9	6	1	2	1	+	1	1	7	5
Meadowlark (species?)	1	3	4	2	+	1	+	2	4		8
*Killdeer		2	2	1		+		2	8	3	5
Brown-headed cowbird	1	5	1	+	1			3	3	6	1
Starling		4	2				+			1	13
Barn swallow	1	+	1	+		2	1		+	3	7
Robin	2	3	1	1	1		+	2	3		
Common crow	2		+	2	3				1		4
*Vesper sparrow	4	6	1	+	1	+					
Brown thrasher	+	+		1	3		1	2	2	2	
Yellow-shafted flicker	3	1	+	1	2	+		1	1		
Eastern kingbird	2	+	+	+	+		+	1	3	1	1
Field sparrow	1	1		+	+	1	+	1	2	1	1
American goldfinch	2	1	2	+	1		+	1	+		1
Dickcissel		1	1	1	+	1	+			1	1
Indigo bunting	+	+	+	+	+		+	+	1	1	1
Mockingbird								1	4	1	
Red-headed woodpecker	+	+		+	1			1	3		
Upland plover	1		1	+	1	1		+	1		
Chimney swift	1			+	1	1	1	+			1
Lark sparrow					+		1	1	3		
Loggerhead shrike	1		+	1	+	1		+	1		
Blue jay	1	+	+	+	+			+	1		
Bobwhite		+						1	1	2	
Eastern bluebird				+	+	+		1	2		
Sparrow hawk				+	1		+	1	1		
Cardinal						+		+	1		1
Catbird	+			+				+	1		
Ring-necked pheasant						2					
Spotted sandpiper		+	1						+		
Purple martin			+	+					1		
Bobolink	+	1	+								
Yellowthroat	+			+				+	+		
Turkey vulture									+		1
Eastern phoebe								+		1	
Chipping sparrow			1					+			
Orchard oriole				+				+	+		
Greater prairie chicken	1										
Brewer's blackbird			1								
Traill's flycatcher				+				+			
Rufous-sided towhee								+	+		

Table 5.—Continued

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909	1957	1958	1907	1909	1957	1958	1907	1909	1957	1958
	(351)	(317)	(299)	(668)	(488)	(328)	(290)	(550)	(433)	(103)	(156)
Song sparrow.....	---	---	+	+	---	---	---	---	---	---	---
Great blue heron.....	---	---	---	---	---	---	---	+	---	---	---
Black-crowned night heron.....	+	---	---	---	---	---	---	---	---	---	---
Red-tailed hawk.....	---	---	---	---	---	---	+	---	---	---	---
Red-shouldered hawk.....	---	---	---	---	---	---	---	+	---	---	---
Yellow-billed cuckoo.....	---	---	---	---	---	+	---	---	---	---	---
Common night-hawk.....	---	---	---	+	---	---	---	---	---	---	---
Belted kingfisher.....	---	---	---	+	---	---	---	---	---	---	---
Downy wood-pecker.....	---	---	---	---	---	---	---	+	---	---	---
Tree swallow.....	---	---	+	---	---	---	---	---	---	---	---
Bewick's wren.....	---	---	---	---	---	---	---	---	+	---	---
Carolina wren.....	---	---	---	---	---	---	---	+	---	---	---
Baltimore oriole.....	---	---	---	---	---	---	---	---	+	---	---
Rose-breasted grosbeak.....	+	---	---	---	---	---	---	---	---	---	---
Grasshopper sparrow.....	---	---	---	+	---	---	---	---	---	---	---
Unidentified bird.....	3	1	2	+	1	2	---	1	1	1	2
Total birds per 100 acres.....	63	86	88	35	47	73	32	45	74	47	72
Number of species.....	28	24	28	35	25	19	19	37	36	17	19



Fig. 11.—Cornfield habitat at the stage of growth encountered at the time of the June censuses. Photograph taken in Champaign County, June, 1958, by Jean W. Graber.

and 1909 in all zones censused than in 1957 and 1958, fig. 19. The pattern is one that can be observed over and over for the open-field habitats; that is, in these habitats the earlier avifauna of common species was more varied than the recent. Related to this change is the fact that only three species (horned lark, red-winged blackbird, and barn swallow) comprised more of the cornfield population in 1957-1958 than in 1907-1909, while at least nine species were less prominent in the recent than the earlier cornfield avifauna, fig. 12.

In northern and central Illinois, by 1957 the horned lark had become the predominant cornfield species, a change reflected in the density figures, table 5. The change in the southern zone was less pronounced.

The nesting avifauna for cornfields probably is composed principally of three species: the horned lark, vesper sparrow, and killdeer.

Because so much of the summer avifauna of cornfields does not breed in this habitat, the list of species in table 5 must reflect marginal or edge habitat to some

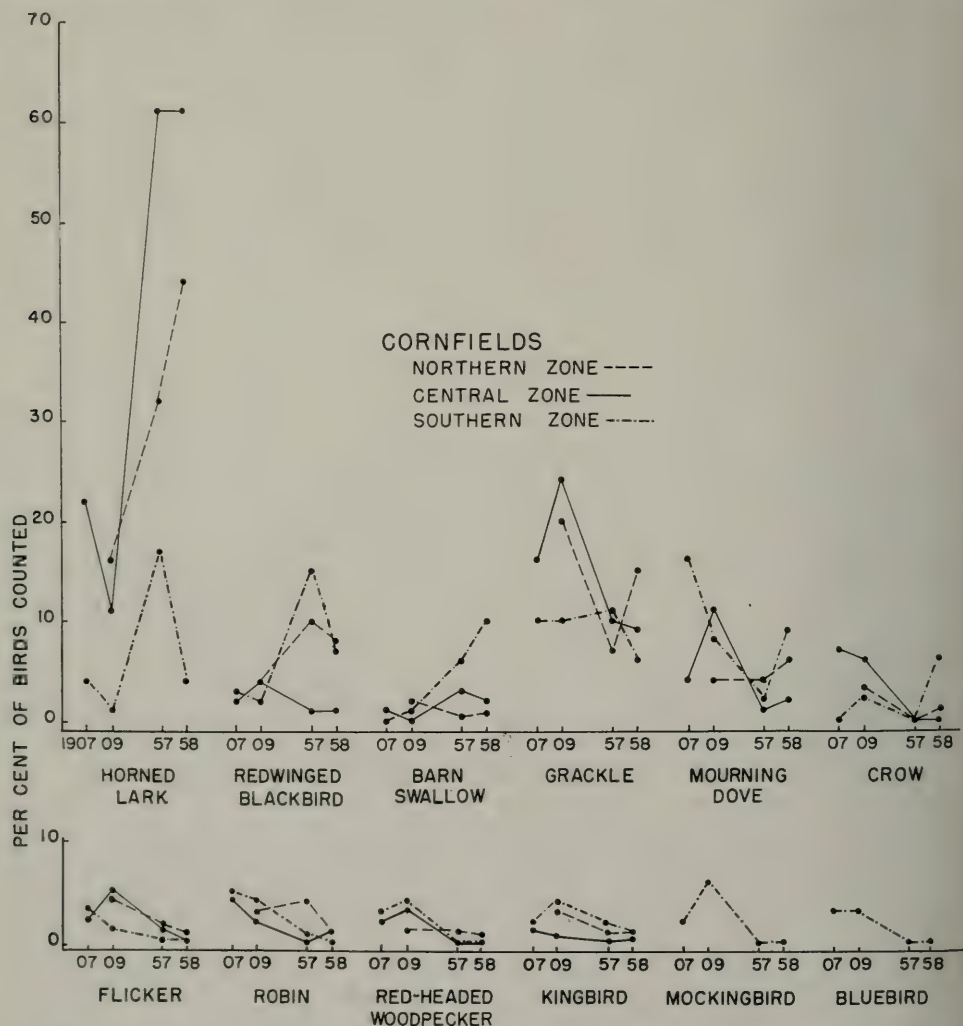


Fig. 12.—Relative abundance of common species of birds censused in cornfields of the northern, central, and southern zones of Illinois in the summers of 1907, 1909, 1957, and 1958. Only those species are included that showed changes in relative abundance (per cent of all birds counted in cornfields) between 1909 and 1957.

extent. In all of the census years, regional differences were apparent. The cornfield avifauna of the central zone in summer was poorer both in number of species and in density of population than that of either the northern or the southern zone.

Soybean Fields (Summer)

Soybean acreage increased in Illinois from a few thousand acres before 1920 to more than 4,000,000 in 1954 (Ross & Case 1956:71); 777 acres of soybean fields were censused in 1957-1958.

Soybeans were one of the crops characterized by considerable areas of bare ground at the start of the nesting season. In early June, at the start of censusing, the plants were less than 6 inches in height; by the end of the summer census season they reached 12 inches or more. During this period, the areas of bare earth were gradually closed in by the plants, and the habitat probably became less desirable for the open-field bird species that predominate in bare-ground habitats.

Soybean fields were about the poorest of bird habitats, both in number of species and number of individual birds, figs. 22-24.

The average number of birds per acre of soybeans for the various years and zones in summer ranged from 0.1 to 0.9. Populations tended to be lowest in the southern zone, tables 6 and 7. In central Illinois, the zone for which we had the largest samples, mean densities were 0.9 bird per acre in 1957 and 0.5 in 1958, table 6. Maximum variation of bird populations in any one zone in consecutive census years was from 0.1 to 0.5 bird per acre, in southern Illinois.

At least 28 species of birds were identified in soybean fields in the summers of 1957 and 1958, table 7. Though no species was recorded in this habitat in both years in all regions, the horned lark, grackle, redwinged blackbird, mourning dove, and goldfinch were reported with high frequency. Probably only the horned lark and the vesper sparrow nested regularly in this habitat; the horned lark was the predominant species.

Plowed Fields (Summer)

In early summer, relatively little Illinois land can be classed as plowed fields.

Only 335 acres of this habitat were censused in summers of the two study periods. Despite the total lack of cover, plowed fields had avifaunal associations about comparable to those of cornfields and soybean fields.

Bird population densities in plowed fields in summer varied from 0.6 to 1.4 birds per acre (57 birds per 100 acres in 1907 to 140 birds per 100 acres in 1957, table 8). In the southern zone, the only one in which large areas of plowed fields were censused, these fields held populations of about 0.6 bird per acre in 1957-1958, indicating relatively poor habitat.

Twenty-nine species of birds were identified in plowed fields in summer, table 8; this fauna was slightly richer in species than that found in urban residential areas. Probably a very low percentage of the species found in plowed fields actually nested in this habitat. Probable nesting species were the horned lark and the killdeer.

Only in the southern zone was the census area of plowed fields large enough to warrant avifaunal comparisons between the two census periods. In this zone, 10 species of birds comprised the common summer avifauna of plowed fields censused in 1907 and only 7 species in 1958, fig. 19. In plowed fields, as in soybean fields and cornfields, the horned lark was the predominant summer species, figs. 12 and 13 and table 7.

Oat Fields (Summer)

The acreage of oats in Illinois decreased from about 4,300,000 acres in 1907 to 2,800,000 acres in 1957. The reduction was accompanied by an increase in soybean production. In all census years, oat production was higher in the northern two-thirds of the state than in the southern third.

In summers of the two study periods, 1,319 acres of oats fields were censused, table 3, only about 300 acres in 1957-1958. Only 10 acres were censused in the southern zone in 1957-1958. At the time of the summer censuses, the oat plants had attained nearly full growth (12-18 inches) and were headed out. The fields were green in the early part of the census and ripened before the end of July. Most fields had scattered weeds that produced

Table 6.—Statistical data on summer bird populations in Illinois soybean fields as determined by strip censuses in the three zones. Data are (1) from all soybean fields censused and (2) from sample areas (each 10 acres or more) in these fields.

ZONE AND YEAR	ALL SOYBEAN FIELDS CENSUSED		SAMPLE AREAS					
	Acres	Birds Per Acre	Number	Birds Per Acre				
				Range	Mean	Standard Deviation	Standard Error	Mean $\pm$ 2 S.E.
Northern								
1957	24	0.4	---	---	---	---	---	---
1958	143	0.7	6	0.1-2.1	0.8	---	---	---
Central								
1957	250	0.9	9	0.4-1.5	0.9	0.4	0.1	0.7-1.1
1958	239	0.5	9	0.2-0.9	0.6	0.2	0.1	0.4-0.8
Southern								
1957	46	0.1	3	0.0-0.2	0.1	---	---	---
1958	75	0.5	4	0.2-0.5	0.3	---	---	---

Table 7.—Summer avifauna in Illinois soybean fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
	1957 (24)	1958 (143)	1957 (250)	1958 (239)	1957 (46)	1958 (75)
*Horned lark	---	33	57	36	---	11
Common grackle	21	10	4	1	---	4
Redwinged blackbird	12	5	2	2	---	7
Mourning dove	---	4	6	2	2	9
House sparrow	---	2	8	3	---	3
Meadowlark (species?)	---	3	3	2	---	3
American goldfinch	4	3	1	1	2	---
Killdeer	---	2	---	---	---	7
Barn swallow	---	1	+	2	---	5
Ring-necked pheasant	4	---	---	---	---	---
Spotted sandpiper	4	---	---	---	---	---
Indigo bunting	---	---	+	+	---	3
Robin	---	---	1	---	2	---
*Vesper sparrow	---	3	---	---	---	---
Chimney swift	---	---	---	2	---	---
Starling	---	1	---	1	---	---
Mockingbird	---	---	+	---	---	1
Dickcissel	---	---	1	+	---	---
Purple martin	---	1	---	---	---	---
Savannah sparrow	---	1	---	---	---	---
Lark sparrow	---	---	1	---	---	---
Field sparrow	---	1	---	---	---	---
Turkey vulture	---	---	+	---	---	---
Bobwhite	---	---	+	---	---	---
Upland plover	---	---	+	---	---	---
Loggerhead shrike	---	---	+	---	---	---
*Brown-headed cowbird	---	---	---	+	---	---
Grasshopper sparrow	---	---	---	+	---	---
Unidentified bird	---	1	1	1	---	---
Total birds per 100 acres	45	71	88	55	6	53
Number of species	5	14	17	14	3	10

Table 8.—Summer avifauna in Illinois plowed fields (birds per 100 acres) as determined by strip censuses in two zones. Figures in parentheses indicate numbers of acres censused.

SPECIES	CENTRAL ZONE		SOUTHERN ZONE		
	1957 (25)	1907 (68)	1909 (66)	1957 (83)	1958 (56)
Horned lark	92	6	15	13	14
Brown-headed cowbird	8	1	35	4	9
Mourning dove	12	9	21	7	7
Killdeer	---	4	---	17	---
Lark sparrow	16	---	4	---	---
Robin	---	7	8	2	---
Common grackle	---	1	8	2	5
Eastern kingbird	8	4	1	2	---
House sparrow	---	3	9	---	3
Redwinged blackbird	---	1	---	4	7
Eastern meadowlark	---	1	1	6	3
Field sparrow	---	---	8	---	---
Brown thrasher	---	1	6	---	---
Indigo bunting	---	4	---	1	2
Eastern bluebird	---	---	6	---	---
Red-tailed hawk	4	---	---	---	---
Red-headed woodpecker	---	4	---	---	---
Common crow	---	---	---	2	2
Bewick's wren	---	4	---	---	---
Mockingbird	---	---	4	---	---
Loggerhead shrike	---	1	3	---	---
Chimney swift	---	3	---	---	---
Dickcissel	---	---	---	1	2
Yellow-shafted flicker	---	---	---	---	2
Red-shouldered hawk	---	---	---	1	---
Bobwhite	---	---	1	---	---
Upland plover	---	1	---	---	---
Black-billed cuckoo	---	1	---	---	---
Downy woodpecker	---	1	---	---	---
Total birds per 100 acres	140	57	130	62	56
Number of species	6	19	15	13	11

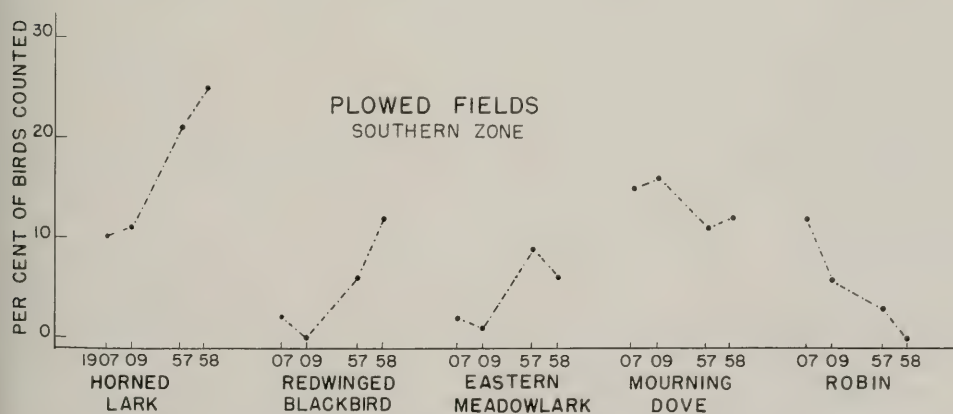


Fig. 13.—Relative abundance of common species of birds censused in plowed fields of the southern zone of Illinois in the summers of 1907, 1909, 1957, and 1958. Only those species are included that showed changes in relative abundance (per cent of all birds counted in plowed fields) between 1909 and 1957.

an aspect more like that of hayfields than other grain crops, and the avifauna showed some resemblance to the nesting avifauna in hayfields.

For all census years and zones, mean densities of summer bird populations in oats varied from 0.5 to 2.7 birds per acre; the greatest variation in consecutive years

Table 9.—Statistical data on summer bird populations in Illinois oat fields as determined by strip censuses in the three zones. Data are (1) from all oat fields censused and (2) from sample areas (each 10 acres or more) in these fields. The data from sample areas are for breeding species only.

ZONE AND YEAR	ALL OAT FIELDS CENSUSED			SAMPLE AREAS		
	Acres	Birds Per Acre		Number	Birds Per Acre (Breeding Species)	
		All Species	Breeding Species Only		Observed Range	Mean
Northern						
1909	241	0.5	0.1	7	0.0-0.3	0.1
1957	95	2.7	2.0	5	0.9-3.8	2.0
1958	71	1.3	1.2	3	0.2-1.8	---
Central						
1907	408	0.6	0.2	10	0.0-0.8	0.2
1909	188	0.6	0.3	6	0.1-0.4	0.3
1957	67	1.1	0.7	4	0.1-0.4	---
1958	56	1.0	0.3	2	0.2-0.6	---
Southern						
1907	145	0.5	0.2	8	0.0-0.7	0.2
1909	38	1.0	0.6	2	---	---

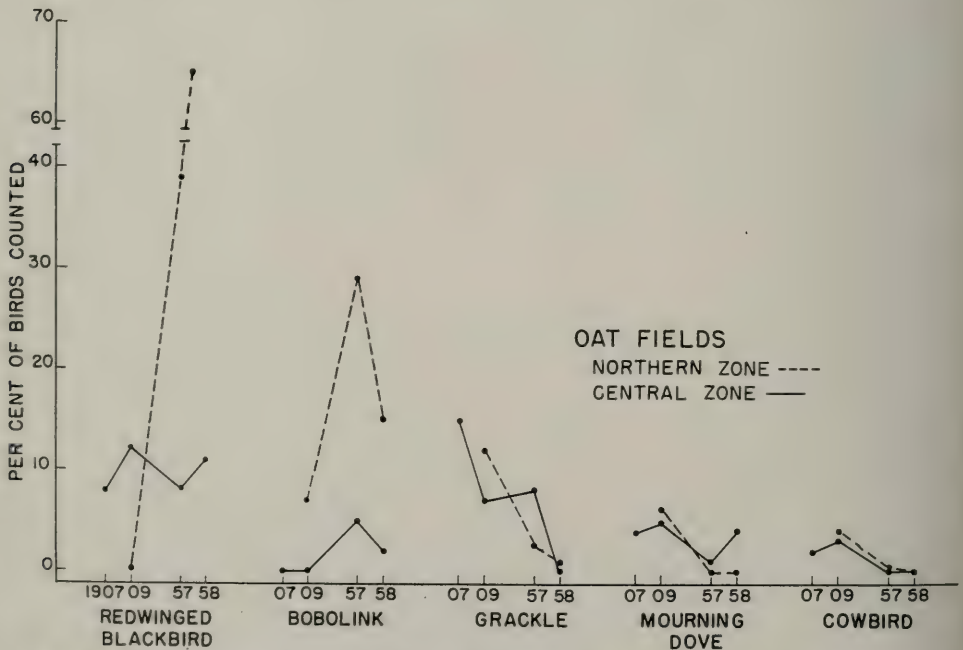


Fig. 14.—Relative abundance of common species of birds censused in oat fields of the northern and central zones of Illinois in the summers of 1907, 1909, 1957, and 1958. Only those species are included that showed changes in relative abundance (per cent of all birds counted in oat fields) between 1909 and 1957.

was from 2.7 birds per acre in 1957 to 1.3 in 1958, in the northern zone, table 9. Densities were higher in the northern than in other zones and in the later than in the early series of censuses. In 1907–1909, the density of bird populations in oat fields ranged from 0.5 to 1.0 bird per acre and averaged 0.7, about comparable to density of the populations in cornfields. In 1957 and 1958, the population in oat

Table 10.—Summer avifauna in Illinois oat fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE	
	1909	1957	1958	1907	1909	1957	1958	1907	1909
	(241)	(95)	(71)	(408)	(188)	(67)	(56)	(145)	(38)
*Redwinged blackbird.....	.....	107	87	5	8	9	11	1	18
House sparrow.....	17	23	3	8	8	13	59	7	8
*Bobolink.....	4	78	20	.....	.....	6	2	.....	.....
*Meadowlark (species?).....	1	11	3	5	6	6	9	13	26
Common grackle.....	7	9	1	9	5	9	.....	1	21
*Dickcissel.....	4	1	.....	5	10	25	9	1	5
*Horned lark.....	1	2	.....	7	+	21	.....	1	.....
Mourning dove.....	3	.....	.....	2	3	1	+	+	5
Bobwhite.....	.....	.....	.....	+	2	1	.....	5	8
*Ring-necked pheasant.....	.....	2	13	.....	.....	.....	.....	.....	.....
American goldfinch.....	2	9	3	1	.....	.....	.....	.....	.....
Barn swallow.....	1	1	1	+	+	+	+	.....	.....
Yellow-shafted flicker.....	1	1	1	1	2	1	.....	1	.....
Common crow.....	5	.....	.....	+	+	.....	.....	2	.....
Robin.....	+	1	.....	.....	1	1	.....	1	3
Eastern kingbird.....	+	.....	.....	1	2	3	.....	.....	.....
Brown thrasher.....	+	.....	.....	+	3	.....	.....	.....	3
Starling.....	.....	6	.....	.....	.....	.....	.....	.....	.....
*Brown-headed cowbird.....	2	1	.....	1	2	.....	.....	.....	.....
Killdeer.....	.....	.....	.....	1	.....	4	.....	.....	.....
*Grasshopper sparrow.....	.....	.....	1	4	.....	.....	.....	.....	.....
Upland plover.....	.....	.....	.....	.....	+	3	.....	1	.....
Yellowthroat.....	.....	.....	.....	.....	+	.....	.....	1	3
Sparrow hawk.....	.....	.....	.....	+	.....	.....	.....	.....	3
Purple martin.....	.....	3	+	.....	.....	.....	.....	.....	.....
Indigo bunting.....	.....	1	.....	+	1	.....	.....	1	.....
Field sparrow.....	.....	.....	.....	.....	2	.....	.....	1	.....
*Lark sparrow.....	.....	.....	.....	+	+	.....	.....	2	.....
Catbird.....	+	.....	.....	.....	.....	.....	.....	2	.....
Chimney swift.....	.....	1	.....	1	.....	.....	.....	.....	.....
Red-headed woodpecker.....	1	.....	.....	.....	1	.....	.....	.....	.....
Loggerhead shrike.....	.....	.....	.....	1	.....	.....	.....	1	.....
Cardinal.....	.....	.....	.....	.....	.....	.....	2	.....	.....
*Vesper sparrow.....	+	1	.....	+	+	.....	.....	.....	.....
Song sparrow.....	+	.....	.....	+	1	.....	.....	.....	.....
Cliff swallow.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Blue jay.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Eastern bluebird.....	1	.....	.....	.....	.....	.....	.....	.....	.....
Savannah sparrow.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Bachman's sparrow.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Black-crowned night heron.....	+	.....	.....	.....	.....	.....	.....	.....	.....
Eastern phoebe.....	.....	.....	.....	+	.....	.....	.....	.....	.....
Baltimore oriole.....	+	.....	.....	.....	.....	.....	.....	.....	.....
Chipping sparrow.....	.....	.....	.....	.....	+	.....	.....	.....	.....
Unidentified bird.....	2	10	.....	2	3	4	.....	.....	.....
Total birds per 100 acres.....	55	268	134	61	65	111	100	48	103
Number of species.....	22	18	11	27	24	15	8	20	11

fields ranged from 1.0 to 2.7 birds per acre and averaged 1.5, a density well above that for cornfields.

Population densities of breeding species showed minimum and maximum figures for 1907-1909 of 0.1 bird per acre (in the

Table 11.—Statistical data on summer bird populations in Illinois wheat fields as determined by strip censuses in two zones. Data are (1) from all wheat fields censused and (2) from sample areas (each 10 acres or more) in these fields. The data from sample areas are for breeding species only.

ZONE AND YEAR	ALL WHEAT FIELDS CENSUSED			SAMPLE AREAS		
	Acres	Birds Per Acre		Number	Birds Per Acre (Breeding Species)	
		All Species	Breeding Species Only		Observed Range	Mean
Central 1909	141	0.8	0.2	4	0.0-0.4	0.2
Southern 1907	227	0.8	0.2	10	0.0-0.5	0.3
1909	75	0.6	0.1	3	0.1-0.2	0.2
1957	97	0.6	0.3	4	0.0-1.4	0.4



Fig. 15.—Relative abundance of common species of birds censused in wheat fields of the central and southern zones of Illinois in the summers of 1907, 1909, 1957, and 1958. Only those species are included that showed changes in relative abundance (per cent of all birds counted in wheat fields) between 1909 and 1957.

northern zone) and 0.6 per acre (in the southern zone); for 1957-1958, these figures were 0.3 bird per acre (in the central zone) and 2.0 birds per acre (in the northern zone), table 9.

Because census samples were small for the later years, we must be cautious in drawing conclusions, but the data indicate that summer bird population densities increased in oat fields between 1909 and 1957. The change in population densities of birds in this habitat can probably be attributed to population changes in a few species, particularly the redwinged blackbird and the bobolink, fig. 14.

At least 44 species of birds were recorded in oat fields in summers of the two census periods combined, table 10, but only 2, the house sparrow and the eastern meadowlark, were found in all zones and in all years. The number of species recorded was considerably greater in 1907-1909 than in 1957-1958, probably because of the greater acreage covered in the early census period.

Wheat Fields (Summer)

The acreage of Illinois land planted to wheat has varied greatly since 1909. From about 2,000,000 acres in the period 1890-

Table 12.—Summer avifauna in Illinois wheat fields (birds per 100 acres) as determined by strip censuses in two zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres; * indicates breeding species in this habitat.

SPECIES	CENTRAL ZONE				SOUTHERN ZONE			
	1907 (28)	1909 (141)	1957 (32)	1958 (31)	1907 (227)	1909 (75)	1957 (97)	1958 (41)
House sparrow	257	14	---	3	25	7	---	7
*Redwinged blackbird	4	11	---	---	5	2	20	113
*Dickcissel	7	7	19	26	8	---	4	12
Mourning dove	18	3	---	---	18	5	6	12
Common grackle	7	11	---	---	3	2	3	29
Indigo bunting	---	---	9	3	---	9	3	22
*Meadowlark (species?)	11	3	6	---	12	2	5	5
Field sparrow	---	---	6	---	2	9	4	2
Bobwhite	4	---	---	---	2	9	---	5
Barn swallow	---	---	3	6	---	---	1	10
Horned lark	---	16	---	---	---	---	1	---
Starling	---	---	---	13	---	---	---	---
*Grasshopper sparrow	7	---	3	---	---	2	---	---
Purple martin	11	---	---	---	---	---	---	---
*Brown-headed cowbird	4	1	---	---	---	---	1	2
Rough-winged swallow	---	---	3	---	---	---	6	---
Chimney swift	---	---	---	6	1	---	---	---
Red-headed woodpecker	---	4	---	---	---	3	---	---
Yellowthroat	---	---	---	---	1	2	1	---
Song sparrow	---	1	---	3	---	---	---	---
Greater prairie chicken	4	---	---	---	---	---	---	---
Yellow-billed cuckoo	---	1	---	---	+	2	---	---
Sparrow hawk	---	---	---	---	---	3	---	---
Brown thrasher	---	1	---	---	---	2	---	---
Robin	---	---	---	---	1	2	---	---
Upland plover	---	---	---	---	1	---	---	---
Cliff swallow	---	1	---	---	---	---	---	---
Common crow	---	1	---	---	---	---	---	---
Mockingbird	---	1	---	---	---	---	---	---
Orchard oriole	---	---	---	---	1	---	---	---
Cardinal	---	---	---	---	---	---	1	---
Catbird	---	---	---	---	+	---	---	---
Lark sparrow	---	---	---	---	+	---	---	---
Unidentified bird	---	1	9	6	1	3	1	2
Total birds per 100 acres	334	77	58	66	82	64	57	221
Number of species	11	15	7	7	16	15	13	11

1905, wheat land increased to over 4,000,000 acres in 1919 and then decreased to an average of 1,500,000 per year in the period 1940-1950 (Ross & Case 1956: 70). This crop in Illinois is grown mainly in the southern and central zones, and virtually all of the 773 acres of wheat fields censused for birds represented these zones.

At the time censusing started each year, the wheat plants were 1.5-2 feet tall, green, and headed out. The plants ripened during June and July and were cut in July and August. Ripe wheat would appear to be an inhospitably warm habitat for birds.

Wheat fields were found to be a relatively poor habitat for birds in summer, figs. 22-24, supporting populations slightly higher than those in the crops of corn and beans. Basic statistical data for years in which the largest acreages were censused are presented in table 11. For these years the number of birds per acre in wheat fields ranged from 0.6 to 0.8, in southern Illinois. Breeding species usually comprised one-fourth to one-half of the total population in wheat fields and varied from 0.1 to 0.3 bird per acre. The

data, though meager, suggest that the density of wheat field populations was about the same in the central and southern zones and in the two census periods.

At least 33 species of birds were identified in wheat fields in summer, table 12. No species was reported in all years in both the central and southern zones, but the mourning dove was a common species in all years in the southern zone. In both zones, the eastern meadowlark and the dickcissel were recorded with very high frequency. These species, the redwinged blackbird, and the grasshopper sparrow nested in wheat fields at least in the early part of the summer, though wheat is probably poor nesting habitat for any species.

In the central zone, the dickcissel used this habitat more in 1957-1958 than in 1907-1909, table 12; in the southern zone, the redwinged blackbird was the predominant species on wheat land at the time of the second survey, fig. 15.

Pastures (Summer)

The censuses indicated a marked reduction in pasture acreage between 1909 and 1957, particularly in the central and



Fig. 16.—Pastureland with trees. The acreage of savanna-like habitats of this kind was greatly reduced between 1909 and 1957. The reduction contributed importantly to a loss of species variety in the avifauna of many parts of Illinois. Photograph taken near Ogden, Illinois, May 28, 1907, by Alfred O. Gross.

southern zones. In summers of the two study periods, 2,087 acres of pasture were censused for birds, only one-fourth of this total in 1957-1958. We estimated that the area of nonwoodland pasture declined from about 6,100,000 acres in 1907 to 2,000,000 in 1957.

The pastures referred to in this report were virtually all stands of bluegrass (*Poa pratensis*), some with scattered low

in the central zone. Bird population densities were highest in the central and northern zones and tended to be higher in the second census period than in the first.

A clearer picture of the pasture populations and their variations is obtained if only known breeding species are considered, tables 13 and 14 and fig. 17. The average number of breeding birds per acre of pasture in the various censuses ranged

Table 13.—Statistical data on summer bird populations in Illinois pastures as determined by strip censuses in the three zones. Data are sample areas (each 5 acres or more) in these breeding species only.

ZONE AND YEAR	ALL PASTURES CENSUSED			SAMPLE AREAS					
	Acres	Birds Per Acre		Num- ber	Birds Per Acre (Breeding Species Only)				
		All Species	Breeding Species Only		Range	Mean	Standard Deviation	Standard Error	Mean $\pm$ 2 S.E.
Northern									
1909.....	193	2.2	0.8	7	0.1-1.4	0.6	0.5	0.2	0.2-1.0
1957.....	147	2.1	1.3	12	0.7-2.3	1.4	0.5	0.1	1.2-1.6
1958.....	132	2.3	1.4	13	0.1-2.9	1.0	0.9	0.3	0.4-1.6
Central									
1907.....	287	1.5	0.5	12	0.1-0.9	0.5	---	---	---
1909.....	155	2.2	0.9	7	0.3-1.1	0.6	---	---	---
1907-1909.....	442	---	---	19	0.1-1.1	0.6	0.3	0.1	0.4-0.8
1957.....	54	2.9	1.2	6	0.7-1.7	1.2	---	---	---
1958.....	118	2.2	0.9	7	0.2-1.3	0.9	---	---	---
1957-1958.....	172	---	---	13	0.2-1.7	1.0	0.4	0.1	0.8-1.2
Southern									
1907.....	601	1.3	0.5	21	0.1-1.6	0.5	0.3	0.2	0.1-0.9
1909.....	281	1.6	0.7	11	0.3-1.1	0.7	0.2	0.1	0.5-0.9
1957.....	72	1.5	0.8	6	0.3-1.5	1.1	---	---	---
1958.....	48	2.1	1.2	7	0.5-1.9	1.1	---	---	---
1957-1958.....	120	---	---	13	0.3-1.9	1.1	0.5	0.1	0.9-1.3

woody plants (6 inches-2 feet high) and a few with isolated trees, fig. 16. The grass cover was dense, usually 4-10 inches high and forming a continuous mat, which was grazed by cattle or, rarely, by sheep. The characteristics of bluegrass pastures as bird habitats probably have not changed greatly in the present century.

Both quantitatively and qualitatively, pasture was shown to be a rich open-country habitat for birds, figs. 22-24 and tables 13 and 14. Average summer densities of birds (all species) per acre in pasture for the two census periods and the three zones of the state had a range of 1.3-2.9, table 13. Maximum annual variations in consecutive census years were 1.5-2.2 (1907-1909) and 2.9-2.2 (1957-1958),

from 0.5 to 1.4, table 13. The highest mean population density for 1907-1909 was 0.9 bird per acre and the lowest for 1957-1958 was 0.8. The differences between mean population densities for the two study periods were consistent for all three zones of the state, fig. 17. It seems probable that population densities of breeding birds in Illinois pastures increased, possibly even doubled, during the half century between the two study periods.

At least 76 species of birds were found in pastures, table 14, of which only 7 (eastern meadowlark, house sparrow, grackle, redwinged blackbird, field sparrow, cowbird, and dickcissel) were reported in all census summers of the two

Table 14.—Summer avifauna in Illinois pastures (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909 (193)	1957 (147)	1958 (132)	1907 (287)	1909 (155)	1957 (54)	1958 (118)	1907 (601)	1909 (281)	1957 (72)	1958 (48)
*Meadowlark (species?)	14	35	39	19	21	31	44	20	44	58	56
House sparrow	27	9	11	31	30	52	93	20	7	4	27
Common grackle	28	8	16	15	21	44	1	8	8	11	15
*Redwinged black- bird	11	29	52	1	14	7	10	4	7	4	8
*Field sparrow	6	3	2	5	3	20	19	10	5	11	33
*Brown-headed cowbird	23	6	4	2	31	15	1	2	5	5	8
Barn swallow	7	9	11	2	3	7	2	+	---	7	33
Yellow-shafted flicker	17	3	3	8	15	---	2	3	4	---	---
Robin	12	1	1	10	9	2	2	5	5	4	---
*Grasshopper sparrow	3	7	5	4	2	20	4	2	+	3	---
Starling	---	13	23	---	---	7	1	---	---	5	---
*Savannah spar- row	6	24	17	1	---	---	---	---	---	---	---
*Dickcissel	3	1	1	3	4	15	5	4	1	1	2
Brown thrasher	3	1	---	4	12	---	1	3	9	3	4
Mourning dove	2	4	1	4	7	4	2	5	9	3	---
American gold- finch	2	6	7	---	---	13	4	1	---	1	2
*Bobolink	5	11	17	---	1	---	---	---	---	---	---
*Bobwhite	1	---	---	1	5	2	---	4	7	3	8
*Horned lark	6	---	1	8	---	13	---	2	---	---	---
Eastern king- bird	5	7	4	4	1	---	2	2	4	---	---
Eastern bluebird	1	3	---	1	1	2	1	2	5	8	---
Blue jay	2	1	2	1	3	---	2	3	4	3	---
Red-headed woodpecker	3	1	---	7	4	---	---	2	4	---	---
Common crow	6	---	---	2	6	---	2	1	1	---	---
Orchard oriole	+	---	---	---	---	4	---	3	4	1	4
*Killdeer	1	5	---	1	3	---	2	+	1	---	2
Chimney swift	2	---	---	+	2	---	5	1	+	---	4
*Vesper sparrow	3	7	4	---	---	---	---	---	---	---	---
Indigo bunting	1	---	---	---	1	2	---	+	+	4	4
*Song sparrow	---	4	2	1	3	2	---	---	---	---	---
Mockingbird	---	---	---	---	---	4	---	2	4	1	---
Yellow-billed cuckoo	1	1	---	---	3	4	---	+	---	1	---
*Lark sparrow	---	---	---	1	1	---	2	5	1	---	---
*Upland plover	3	2	---	3	---	---	---	+	1	---	---
House wren	---	---	---	---	---	6	2	---	1	---	---
Baltimore oriole	+	1	---	1	---	2	4	---	---	---	---
Cardinal	---	---	---	---	---	4	---	+	---	3	---
Sparrow hawk	+	---	---	---	1	4	1	+	---	---	---
Catbird	3	1	---	+	---	---	1	+	1	---	---
Bank swallow	4	---	---	---	1	---	---	---	1	---	---
Loggerhead shrike	1	---	---	1	3	---	---	+	---	---	---
Chipping sparrow	3	---	---	---	---	---	---	1	1	---	---
Yellowthroat	+	---	---	---	1	---	---	1	2	---	---
Purple martin	---	---	1	---	---	---	---	1	2	---	---
Bewick's wren	---	---	---	---	---	---	---	+	+	3	---

studies and in all zones of the state. Seventeen species of birds were believed to breed in pastures, table 14.

The meadowlarks appeared to increase their population densities between 1909 and 1957, particularly in the northern and

Table 14.—Continued

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909 (193)	1957 (147)	1958 (132)	1907 (287)	1909 (155)	1957 (54)	1958 (118)	1907 (601)	1909 (281)	1957 (72)	1958 (48)
Tree swallow.....	---	---	1	---	---	2	---	---	---	---	---
Green heron.....	---	---	---	1	1	---	---	+	+	---	---
Turkey vulture.....	---	---	---	---	---	---	---	2	+	---	---
Great crested fly-catcher.....	---	---	---	---	1	---	---	+	+	1	---
Eastern phoebe.....	+	---	---	---	2	---	---	+	---	---	---
Chickadee (species?).....	---	---	---	---	---	2	---	+	---	---	---
Tufted titmouse.....	---	---	---	---	---	---	2	+	---	---	---
Red-tailed hawk.....	---	1	---	1	---	---	---	---	---	---	---
Rough-winged swallow.....	---	1	---	---	---	---	1	---	---	---	---
Bell's vireo.....	---	---	---	---	---	2	---	---	---	---	---
Rufous-sided towhee.....	---	---	---	---	1	---	---	---	1	---	---
Carolina wren.....	---	---	---	---	---	---	---	+	+	1	---
Spotted sandpiper.....	---	---	1	+	---	---	---	---	---	---	---
Common night-hawk.....	---	---	---	+	---	---	---	---	1	---	---
Red-bellied woodpecker.....	---	---	---	---	---	---	---	+	---	1	---
Eastern wood pewee.....	---	1	---	---	---	---	---	---	+	---	---
Red-eyed vireo.....	1	---	---	+	---	---	---	---	---	---	---
Yellow-breasted chat.....	---	---	---	---	---	---	---	+	1	---	---
Black-crowned night heron.....	1	---	---	---	---	---	---	---	---	---	---
*Greater prairie chicken.....	1	---	---	---	---	---	---	---	---	---	---
Ring-necked pheasant.....	---	1	---	---	---	---	---	---	---	---	---
Belted kingfisher.....	---	---	---	---	1	---	---	---	---	---	---
White-breasted nuthatch.....	---	---	---	---	1	---	---	---	---	---	---
Brewer's blackbird.....	---	---	1	---	---	---	---	---	---	---	---
Marsh hawk.....	+	---	---	---	---	---	---	---	---	---	---
American woodcock.....	---	---	---	---	---	---	---	---	+	---	---
Black-billed cuckoo.....	---	---	---	+	---	---	---	---	---	---	---
Hairy woodpecker.....	---	---	---	---	---	---	---	+	---	---	---
Downy woodpecker.....	---	---	---	---	---	---	---	+	---	---	---
Summer tanager.....	---	---	---	---	---	---	---	---	+	---	---
*Bachman's sparrow.....	---	---	---	---	---	---	---	+	---	---	---
Hawk (species?).....	---	---	---	+	---	---	---	---	---	---	---
Unidentified bird.....	3	3	1	1	3	2	5	2	2	1	---
Total birds per 100 acres.....	224	210	228	146	222	294	223	128	157	151	210
Number of species.....	42	32	25	35	36	28	28	49	42	26	15

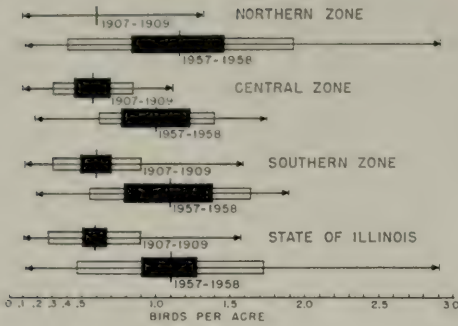


Fig. 17.—Populations of breeding species of birds censused in Illinois pastures in 1907-1909 and 1957-1958. The vertical line through each black rectangle indicates the mean, each open box one standard deviation on either side of the mean, each black rectangle two standard errors on either side of the mean, and each set of arrows the range.

central Illinois zones, as field sparrows did in the central and southern zones, table 14 and fig. 18. Other species showing increases both in relative rank and actual density were the redwinged blackbird (northern zone) and the savannah sparrow (northern zone), fig. 18 and table 14.

Ungrazed Grasslands (Summer)

The acreage of ungrazed grasslands in Illinois is relatively small. We encoun-

tered the habitat principally along railroad rights-of-way and road edges. We estimated that the area of this habitat declined from about 330,000 acres in 1907 to 218,000 in 1957. Excluding roadside grass, 165 acres of this habitat were covered during summers of the two census periods in the northern and southern zones of Illinois.

As a bird habitat, the ungrazed grasslands were closely allied to pastures and fallow fields; woody plants were almost completely lacking in the ungrazed grasslands. The cover of grasses and forbs in the ungrazed grasslands was taller (about 2-3 feet tall) than that in pastures and it was more dense.

Summer bird populations in ungrazed grasslands (excluding roadside grass) were comparable to those in other grassland habitats, with densities varying from approximately 1.2 to 3.9 birds per acre (119 to 386 birds per 100 acres, table 15); the densities in ungrazed grasslands were higher in the northern zone than in the southern zone.

At least 29 species of birds were identified in ungrazed grasslands in summer, table 15. Species common in this habitat were the redwinged blackbird and the eastern and western meadowlarks.

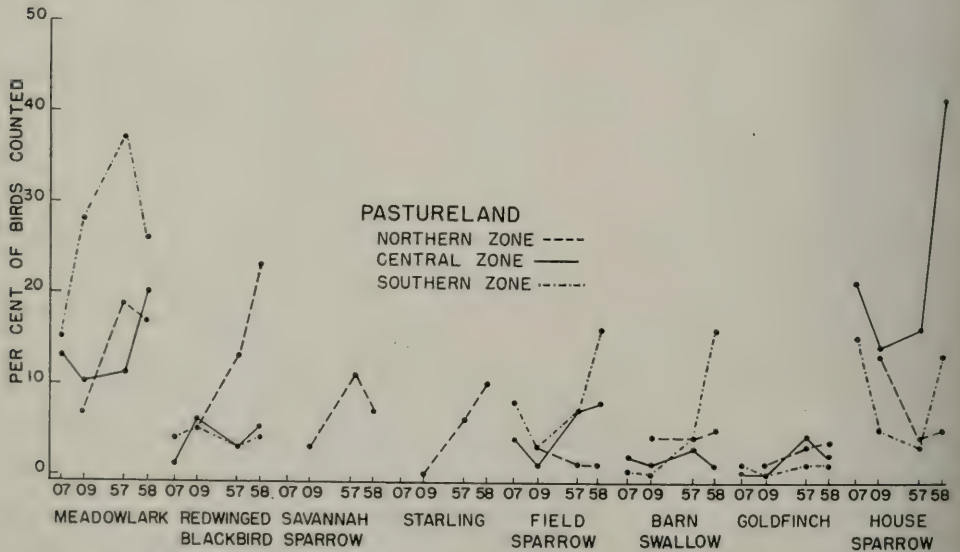


Fig. 18.—Relative abundance of common species of birds censused in pastureland of the northern, central, and southern zones of Illinois in the summers of 1907, 1909, 1957, and 1958. Only those species are included that showed changes in relative abundance (per cent of all birds counted in pastureland) between 1909 and 1957.

Table 15.—Summer avifauna in Illinois ungrazed grasslands (birds per 100 acres) as determined by strip censuses in two zones (open stands only; no roadside or edge grass areas included in this table). Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			SOUTHERN ZONE		
	1909 (15)	1957 (10)	1958 (49)	1907 (33)	1957 (20)	1958 (38)
*Meadowlark (species?)	47	---	66	67	115	37
*Redwinged blackbird	88	19	41	36	30	---
Mourning dove	7	---	98	12	---	13
Horned lark	---	---	113	---	---	13
Common grackle	20	9	---	---	15	21
*Bobolink	54	---	---	---	---	---
Barn swallow	27	9	2	---	---	13
Swamp sparrow	---	38	---	---	---	---
Field sparrow	---	---	---	---	25	5
American goldfinch	---	19	10	---	---	---
Song sparrow	20	9	---	---	---	---
*Grasshopper sparrow	---	---	4	---	15	5
Brown-headed cowbird	---	19	2	---	---	---
House sparrow	---	---	4	9	5	---
*Dickcissel	---	---	4	6	5	3
Robin	7	9	---	---	---	---
*Bobwhite	---	---	6	3	---	3
Blue jay	---	9	---	3	---	---
Common crow	---	---	10	---	---	---
Yellow-shafted flicker	7	---	2	---	---	---
Indigo bunting	---	---	---	---	5	3
*Savannah sparrow	---	---	8	---	---	---
Common egret	---	---	---	---	5	---
American redstart	---	---	---	---	5	---
Red-headed woodpecker	---	---	---	3	---	---
Starling	---	---	---	---	---	3
Killdeer	---	---	2	---	---	---
Bank swallow	---	---	2	---	---	---
Short-billed marsh wren	---	---	2	---	---	---
Unidentified bird	7	38	10	---	5	---
Total birds per 100 acres	284	173	386	139	230	119
Number of species	9	9	17	8	10	11

Fallow Fields (Summer)

As we define the habitat, fallow fields are fields that have been cultivated and then left unused for a year or longer. Such fields support a variety of weeds and grasses that form a fairly dense cover to a height of 2-4 feet. Small shrubs may be found scattered in the older fallow fields, but woody plants are not a dominant feature of the habitat. As a bird habitat, fallow land probably bears closest resemblance to pasture or ungrazed grassland. Agricultural census figures and our own census data indicate that the area of fallow land in Illinois declined from about 1,500,000 acres in 1909 to 1,000,000 in 1957. Logically, acreage of fallow lands

should diminish as a swelling human population increases the demand for cultivated land. In Illinois, largest acreages of this habitat were found in the southern zone; smallest acreages were in the intensively cultivated area of east central Illinois. In the study periods, 682 acres of fallow land were censused, table 3. Population levels of birds in fallow fields in the southern zone did not change greatly in the half century after 1909, table 16. As bird habitat, the fallow land censused was rich in numbers and species, being about comparable to pastureland. The numbers of birds per acre for all census summers in the southern zone ranged from 1.3 to 1.7. Among the breeding spe-

Table 16.—Statistical data on summer bird populations in Illinois fallow fields as determined by strip censuses in the southern zone. Data are (1) from all fallow fields censused in this zone and (2) from sample areas (each 10 acres or more) in these fields. The data from sample areas are for breeding species only.

YEAR	ALL FALLOW FIELDS CENSUSED			SAMPLE AREAS		
	Acres	Birds Per Acre		Number	Birds Per Acre (Breeding Species)	
		All Species	Breeding Species Only		Observed Range	Mean
1907.....	138	1.3	0.5	4	0.1-0.5	0.3
1909.....	181	1.5	0.9	7	0.2-1.4	0.8
1957.....	153	1.5	1.1	6	0.3-1.4	0.8
1958.....	77	1.7	1.0	2	0.8-0.9	0.8

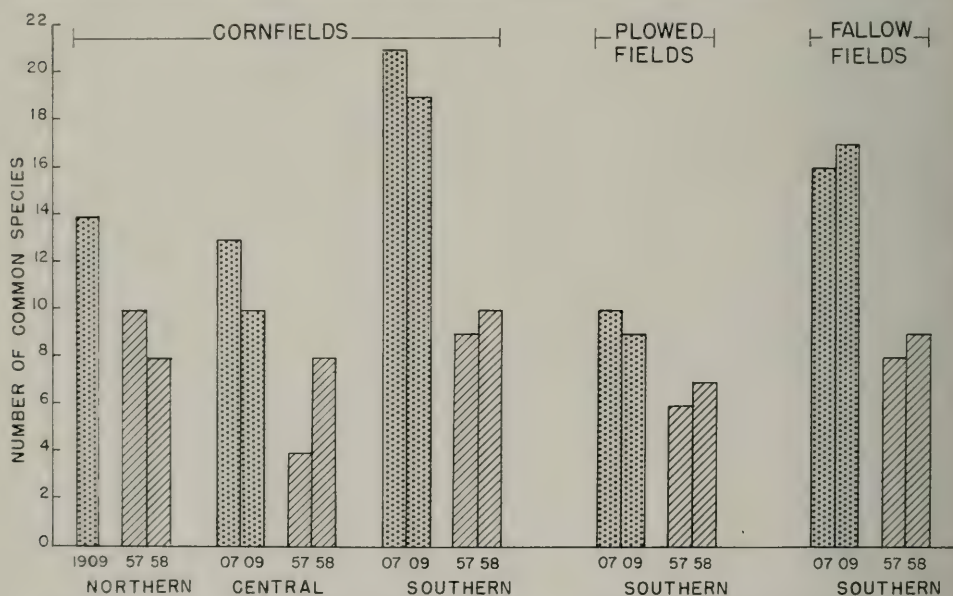


Fig. 19.—Numbers of common bird species (those comprising 85 per cent of the population) in three open-field habitats of Illinois in 1907-1909 and 1957-1958.

cies, which usually constituted at least one-half of the total population, the numbers ranged from 0.5 to 1.1 birds per acre.

At least 50 species of birds were identified in this habitat in summer in the three zones of Illinois. Only the eastern meadowlark and the mourning dove were recorded in all zones in all census years, table 17. The redwinged blackbird, field sparrow, and grackle occurred with high frequency in this habitat. In the southern zone, population increases were noted in this habitat for the mourning dove, red-

winged blackbird, dickcissel, and grackle. The loss of variety in avifauna (after 1909), a loss that characterized other open-field habitats, was apparent also in the fallow field avifauna, fig. 19.

Mixed Hayfields (Summer)

To point out possible differences in the bird populations of various types of hay crops, we segregated data on hayfields of mixed grasses and legumes (called mixed hay) from those of the relatively pure stands of alfalfa, red clover, and sweet

Table 17.—Summer avifauna in Illinois fallow fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE		CENTRAL ZONE	SOUTHERN ZONE			
	1957 (26)	1958 (22)	1957 (25)	1907 (138)	1909 (181)	1957 (153)	1958 (77)
*Mourning dove.....	11	41	56	11	11	38	21
*Redwinged blackbird.....	34	41	60	---	5	22	22
*Meadowlark (species?).....	42	41	12	15	46	16	10
*Dickcissel.....	---	---	116	---	9	12	21
*Horned lark.....	---	81	8	---	---	---	---
Common grackle.....	8	18	---	6	2	10	35
*Field sparrow.....	27	---	8	9	8	12	12
House sparrow.....	---	---	20	26	8	---	8
American goldfinch.....	---	13	16	11	---	6	3
Indigo bunting.....	11	---	12	1	1	10	1
Eastern kingbird.....	---	13	---	6	6	1	---
Brown thrasher.....	11	---	---	1	4	1	---
*Lark sparrow.....	---	4	8	2	3	---	---
*Yellowthroat.....	---	---	1	3	1	10	---
*Grasshopper sparrow.....	---	---	8	---	2	---	4
*Brown-headed cowbird.....	---	4	---	1	2	5	1
Barn swallow.....	---	---	4	---	---	3	5
Cardinal.....	---	---	---	---	2	1	9
Orchard oriole.....	4	---	---	3	3	1	---
Eastern bluebird.....	---	---	---	4	3	3	---
Yellow-headed blackbird.....	---	9	---	---	---	---	---
*Bobwhite.....	---	---	---	3	2	3	---
Yellow-shafted flicker.....	---	4	---	2	2	---	---
Mockingbird.....	---	---	---	3	5	---	---
Starling.....	4	4	---	---	---	---	---
Upland plover.....	---	---	8	---	---	---	---
Blue jay.....	---	---	---	4	1	1	---
*Bewick's wren.....	---	---	---	4	1	---	---
Chimney swift.....	---	---	---	---	2	1	1
Ring-necked pheasant.....	4	---	---	---	---	---	---
Red-headed woodpecker.....	---	---	---	---	4	---	---
Rough-winged swallow.....	---	---	---	---	---	---	4
Savannah sparrow.....	4	---	---	---	---	---	---
Common crow.....	---	---	---	1	2	---	---
Robin.....	---	---	---	3	---	---	---
Sparrow hawk.....	---	---	---	---	2	---	---
Purple martin.....	---	---	---	1	1	---	---
Loggerhead shrike.....	---	---	---	1	1	---	---
Yellow-breasted chat.....	---	---	---	---	1	1	---
Killdeer.....	---	---	---	1	---	---	---
Yellow-billed cuckoo.....	---	---	---	1	---	---	---
Common nighthawk.....	---	---	---	---	1	---	---
Downy woodpecker.....	---	---	---	1	---	---	---
Great crested flycatcher.....	---	---	---	1	---	---	---
Cliff swallow.....	---	---	---	1	---	---	---
Carolina wren.....	---	---	---	1	---	---	---
Rufous-sided towhee.....	---	---	---	---	1	---	---
*Bachman's sparrow.....	---	---	---	---	1	---	---
Chipping sparrow.....	---	---	---	1	---	---	---
Hawk (species?).....	---	---	---	1	---	---	---
Unidentified bird.....	---	4	---	1	4	4	5
Total birds per 100 acres.....	160	277	336	128	149	152	172
Number of species.....	11	12	13	31	32	20	16

clover. The present account concerns mixed hay. During the two study periods, 1,212 acres of this habitat were censused in summer, less than 400 acres of it in 1957-1958, table 3.

The strip census data and published agricultural records indicate that the total acreage of mixed hay in Illinois (over 2,-500,000 acres) was about the same in 1907-1909 as in 1957-1958; the mixed hay acreage declined in the north and increased in the south.

Mixed hay usually forms a dense cover 2 to 3 feet in height at maturity and is generally composed of various mixtures of grasses (timothy, brome, and wild grasses) and legumes (red clover, sweet clover, and alfalfa).

As a bird habitat, mixed hay was fairly rich in species and very rich in numbers of birds, figs. 22-24 and tables 18 and 19. At least 14 species of birds were found to nest in this habitat, table 19. As fig. 5 shows, field-to-field variation of bird populations in this habitat was high. Average densities of birds (all species) per acre in mixed hayfields in summer ranged from 1.1 to 8.2 birds per acre; the numbers of birds per acre in successive census years in one zone ranged from 1.8 in 1957 to 8.2 in 1958, in the central zone, table 18.

Such high variability and the relatively small samples in the later census period make conclusions tenuous, but bird populations in northern zone hayfields appeared to be conspicuously higher in 1957-1958 than in 1909.

Average densities of breeding-bird populations in mixed hayfields ranged from 0.5 to 7.1 birds per acre, table 18. These populations were usually highest in northern Illinois, and almost invariably they were higher in the later than in the early years. The numbers of breeding birds per acre in 1907-1909 ranged from 0.5 to 1.4; in 1957-1958 the range was from 0.8 to 7.1, table 18.

This apparent increase in population density between 1909 and 1958 may be attributable to a few species. Of the 57 or more species found in summer hayfields, table 19, only the eastern meadowlark was reported in all census years and in all zones, though the redwinged blackbird, dickcissel, and grasshopper sparrow were reported with very high frequency. Common hayfield birds are listed in tables 20, 21, and 22. In the hayfield fauna, the meadowlarks were found to be increasingly important from northern to southern latitudes in 1907-1909, as well as in recent census years. In northern Illinois,

Table 18.—Statistical data on summer bird populations in mixed hayfields of Illinois as determined by strip censuses in the three zones. Data are (1) from all mixed hayfields censused and (2) from sample areas (each 4 acres or more) in these fields. The data from sample areas are for breeding species only.

ZONE AND YEAR	ALL MIXED HAYFIELDS				SAMPLE AREAS				
	Acres	Birds Per Acre		Num- ber	Birds Per Acre (Breeding Species Only)				
		All Species	Breeding Species Only		Range	Mean	Standard Deviation	Standard Error	Mean ± 2 S.E.
Northern									
1909.....	175	2.3	1.3	7	0.4-2.6	1.4	0.7	0.3	0.8-2.0
1957.....	91	4.0	3.5	7	1.7-6.4	3.9	1.6	0.6	2.7-5.1
1958.....	30	6.2	4.2	2	----	----	----	----	----
Central									
1907.....	60	1.1	0.5	5	0.2-1.3	0.7	0.4	0.2	0.3-1.1
1909.....	65	2.4	1.4	5	0.7-2.3	1.5	0.7	0.3	0.9-2.1
1957.....	55	1.8	1.6	4	0.1-3.6	2.3	----	----	----
1958.....	24	8.2	7.1	3	0.9-9.3	5.1	----	----	----
Southern									
1907.....	330	1.6	1.1	20	0.0-2.9	0.9	0.7	0.1	0.7-1.1
1909.....	204	1.5	1.0	11	0.5-1.7	1.0	0.4	0.1	0.8-1.2
1957.....	33	1.1	0.8	3	0.2-1.1	0.6	----	----	----
1958.....	26	3.1	2.5	1	----	----	----	----	----

Table 19.—Summer avifauna in mixed hayfields of Illinois (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909	1957	1958	1907	1909	1957	1958	1907	1909	1957	1958
	(175)	(91)	(30)	(60)	(65)	(55)	(24)	(330)	(204)	(33)	(26)
*Redwinged blackbird.....	8	230	220	7	9	31	249	22	12	---	121
*Meadowlark (species?).....	29	25	50	13	53	33	69	57	59	61	74
*Dickcissel.....	25	10	---	15	50	74	212	23	21	6	35
*Bobolink.....	53	75	60	---	---	2	37	---	---	---	---
*Grasshopper sparrow.....	9	1	---	15	18	14	122	4	1	6	4
House sparrow.....	45	13	---	2	35	2	77	12	4	---	---
Common grackle.....	8	7	67	13	11	---	---	6	1	18	---
Mourning dove.....	5	---	17	18	6	5	---	5	7	3	12
*Savannah sparrow.....	2	4	47	---	---	---	---	---	---	---	---
Barn swallow.....	2	3	7	---	9	4	4	---	---	6	8
*Bobwhite.....	1	---	---	---	---	---	8	2	6	9	16
Yellow-shafted flicker.....	7	3	3	5	15	---	---	2	1	---	---
*Brown-headed cowbird.....	2	1	20	---	5	---	---	1	1	---	---
American goldfinch.....	2	3	10	3	---	---	---	1	---	---	8
Robin.....	2	1	7	7	---	---	4	1	2	---	---
Brown thrasher.....	---	---	---	7	3	---	4	1	6	---	---
Starling.....	---	1	---	---	---	---	16	---	---	---	4
*Upland plover.....	1	1	7	---	3	2	---	---	3	---	---
Brewer's blackbird.....	---	---	17	---	---	---	---	---	---	---	---
Common crow.....	---	---	---	---	15	---	---	---	---	---	---
Eastern kingbird.....	3	1	3	2	---	---	---	1	4	---	---
Swamp sparrow.....	1	1	13	---	---	---	---	+	---	---	---
Chimney swift.....	7	---	---	---	1	---	---	5	---	---	---
*Henslow's sparrow.....	---	---	---	---	1	---	12	---	---	---	---
Song sparrow.....	3	---	7	2	1	---	---	---	---	---	---
Killdeer.....	---	1	7	2	---	---	---	+	---	---	---
Horned lark.....	3	---	---	2	---	5	---	---	---	---	---
*Short-billed marsh wren.....	---	---	10	---	---	---	---	---	---	---	---
Yellowthroat.....	---	2	---	---	1	---	---	2	1	---	4
*Vesper sparrow.....	3	3	3	---	---	---	---	---	---	---	---
Field sparrow.....	1	---	---	---	1	---	---	3	4	---	---
Common night-hawk.....	---	---	---	---	---	---	---	---	+	---	8
Ruby-throated hummingbird.....	---	---	---	---	---	---	4	---	---	---	+
Purple martin.....	---	---	7	---	---	---	---	1	---	---	---
Bachman's sparrow.....	---	---	---	---	---	---	---	---	---	---	8
Black tern.....	---	---	7	---	---	---	---	---	---	---	---
Red-headed woodpecker.....	1	---	---	---	1	---	---	1	3	---	---
Indigo bunting.....	1	4	---	---	---	---	---	---	1	---	---
Sparrow hawk.....	---	---	3	---	---	---	---	1	1	---	---
*Ring-necked pheasant.....	---	---	3	---	---	---	---	---	---	---	---

Table 19.—Continued

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE			
	1909 (175)	1957 (91)	1958 (30)	1907 (60)	1909 (65)	1957 (55)	1958 (24)	1907 (330)	1909 (204)	1957 (33)	1958 (26)
Traill's flycatcher.....	—	—	—	—	3	—	—	—	—	—	—
Orchard oriole.....	—	—	—	—	—	—	—	1	2	—	—
Eastern bluebird.....	1	—	—	—	—	—	—	+	1	—	—
Loggerhead shrike.....	—	—	—	1	—	—	—	1	—	—	—
Red-shouldered hawk.....	—	—	—	—	—	—	—	—	1	—	—
*Greater prairie chicken.....	1	—	—	—	—	—	—	—	—	—	—
Yellow-billed cuckoo.....	—	—	—	—	—	—	—	—	1	—	—
Blue jay.....	—	1	—	—	—	—	—	+	+	—	—
Mockingbird.....	—	—	—	—	—	—	—	1	—	—	—
Catbird.....	—	1	—	—	—	—	—	—	—	—	—
Lark sparrow.....	—	—	—	—	—	—	—	1	—	—	—
Green heron.....	—	—	—	—	—	—	—	—	+	—	—
Turkey vulture.....	—	—	—	—	—	—	—	—	+	—	—
Downy wood- pecker.....	—	—	—	—	—	—	—	+	—	—	—
Great crested flycatcher.....	—	—	—	—	—	—	—	—	+	—	—
Eastern phoebe.....	—	—	—	—	—	—	—	—	+	—	—
Cardinal.....	—	—	—	—	—	—	—	+	—	—	—
<i>Melospiza</i> (species?).....	—	2	—	—	—	—	—	—	—	—	—
Unidentified bird	3	10	27	—	3	5	4	3	4	3	4
Total birds per 100 acres.....	229	404	622	114	244	177	822	160	146	112	310
Number of species	27	23	23	16	20	10	13	30	29	7	13

meadowlarks appeared to be relatively less common in the hayfield fauna in 1957 than in 1909, tables 20 and 21, despite the recent spread of the western meadowlark into the northern half of the state. The redwinged blackbird population increased dramatically, both in the absolute terms of birds per acre, table 19, and relative to other species, tables 20 and 21. The bobolink population appeared to increase in the northern and central zones as the dickcissel did in the central zone.

Some impression of the year-to-year variation in the common summer avifauna of hayfields may be obtained from data presented in table 22. The most common species showed only slight variation in rank of abundance between 1907 and 1909.

Clover Fields (Summer)

Relatively pure stands of red clover and sweet clover are important open-field habitats for birds. The random censuses of

birds indicated that the acreage of Illinois land in clover and alfalfa increased in the half century after 1909, but as bird habitats the crops themselves did not change.

Red Clover.—Red clover forms very dense cover 1–2 feet tall. In central Illinois, the crop is usually mowed by mid-June. Harvest dates are 1–2 weeks earlier in southern Illinois and 1–2 weeks later in northern Illinois. If left uncut, the plants finish blooming and begin to dry and fall in July and August.

We estimated that hayfields in which red clover predominated accounted for about 544,000 acres in 1907 and 1,100,000 acres in 1957. In summers of the two census periods, 446 acres of red clover were covered, table 3. This habitat boasted a high population density of birds, usually exceeding that for pasture and other grassland habitats, figs. 22–24. Population densities for all years and zones censused varied from 1.9 to 5.5 birds per

Table 20.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in fields of mixed hay in the three zones of Illinois, summer, 1909.

NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
Species	Per Cent	Species	Per Cent	Species	Per Cent
Bobolink	23	Meadowlark (species?)	21	Eastern meadowlark	38
House sparrow	20	Dickcissel	20	Dickcissel	14
Meadowlark (species?)	13	House sparrow	14	Redwinged blackbird	8
Dickcissel	11	Grasshopper sparrow	7	Mourning dove	5
Grasshopper sparrow	4	Yellow-shafted flicker	6	Brown thrasher	4
Redwinged blackbird	3	Common crow	6	Bobwhite	4
Common grackle	3	Common grackle	4	Field sparrow	3
Chimney swift	3	Barn swallow	4	Eastern kingbird	3
Yellow-shafted flicker	3	Redwinged blackbird	4	House sparrow	3
Mourning dove	2			Upland plover	2
				Red-headed woodpecker	2
Total per cent	85	Total per cent	86	Total per cent	86
Number of species	10	Number of species	9	Number of species	11

Table 21.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in mixed hayfields in the three zones of Illinois, summer, 1957.

NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
Species	Per Cent	Species	Per Cent	Species	Per Cent
Redwinged blackbird	57	Dickcissel	42	Eastern meadowlark	54
Bobolink	19	Meadowlark (species?)	19	Common grackle	16
Meadowlark (species?)	6	Redwinged blackbird	17	Bobwhite	8
House sparrow	3	Grasshopper sparrow	8	Barn swallow	5
				Dickcissel	5
				Grasshopper sparrow	5
Total per cent	85	Total per cent	86	Total per cent	93*
Number of species	4	Number of species	4	Number of species	6*

* Four species made up 83 per cent of the birds counted; six species were included here, three with 5 per cent each.

Table 22.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in mixed hayfields in the southern zone of Illinois, summers, 1907 and 1909.

1907		1909	
Species	Per Cent	Species	Per Cent
Eastern meadowlark	36	Eastern meadowlark	38
Dickcissel	14	Dickcissel	14
Redwinged blackbird	14	Redwinged blackbird	8
House sparrow	7	Mourning dove	5
Common grackle	4	Brown thrasher	4
Mourning dove	3	Bobwhite	4
Chimney swift	3	Field sparrow	3
Grasshopper sparrow	2	Eastern kingbird	3
Bobwhite	2	House sparrow	3
		Upland plover	2
		Red-headed woodpecker	2
Total per cent	85	Total per cent	86
Number of species	9	Number of species	11

acre, table 23. Most of the large samples indicated densities of 2-3 birds per acre. Highest densities occurred in central Illinois. The data suggest an increase in the bird population of this habitat after 1909.

At least 40 species of birds were identified in red clover in summer, table 24. As indicated, the eastern meadowlark, dick-

"alfalfa, bromegrass, Ladino clover, and mixtures of these and other hay crops" (Ross & Case 1956:72). We estimated that sweet clover fields occupied about 114,000 acres of land in Illinois in 1957.

Sweet clover forms a dense cover 3-5 feet or more in height. Only 57 acres of sweet clover were censused for birds, table

Table 23.—Statistical data on summer bird populations in Illinois red clover fields as determined by strip censuses in the three zones. Data are (1) from all red clover fields censused and (2) from sample areas (each 4 acres or more) in these fields. The data from sample areas are for breeding species only.

ZONE AND YEAR	ALL RED CLOVER FIELDS			SAMPLE AREAS					
	Acres	Birds Per Acre		Num- ber	Birds Per Acre (Breeding Species Only)				
		All Species	Breeding Species Only		Range	Mean	Standard Deviation	Standard Error	Mean $\pm$ 2 S.E.
Northern									
1957.....	58	2.9	2.0	6	0.7-4.4	2.5	---	---	---
1958.....	53	2.6	1.9	5	1.0-3.6	2.5	---	---	---
Both years ..	111	---	---	11	0.7-4.4	2.5	1.1	0.3	1.9-3.1
Central									
1907.....	32	3.0	0.8	3	0.2-1.0	0.8	---	---	---
1909.....	14	3.8	1.3	2	---	1.5	---	---	---
1957.....	23	4.3	2.0	2	---	1.6	---	---	---
1958.....	67	5.5	2.0	6	0.4-3.8	2.0	1.2	0.4	1.2-2.8
Southern									
1907.....	93	1.9	1.5	9	0.5-2.3	1.3	0.6	0.2	0.9-1.7
1909.....	6	---	---	---	---	---	---	---	---
1957.....	66	2.6	1.7	7	0.0-2.4	1.2	0.8	0.3	0.6-1.8
1958.....	19	4.3	3.0	---	---	---	---	---	---

cissel, grackle, and grasshopper sparrow were found with high frequency in this habitat. At least 11 species, the redwinged blackbird, dickcissel, eastern and western meadowlarks, bobolink, grasshopper sparrow, savannah sparrow, cowbird, prairie chicken, bobwhite, and pheasant, were breeding birds in red clover.

In this summer habitat, the redwinged blackbird populations increased dramatically in the period between the two surveys in central and southern Illinois, tables 24 and 25. There were indications of increasing populations of dickcissel, savannah sparrow, and meadowlarks in the northern zone. The grasshopper sparrow population may have declined in the northern zone.

Sweet Clover.—Sweet clover became popular as an Illinois hay crop after 1925, but the acreage of this plant has decreased in recent years. It has been replaced by

3. Though the sample was small, it showed that the avifauna of sweet clover fields was obviously similar to that found in other hay crops with high population densities and relatively large numbers of species. Population densities for all species in sweet clover in the summers and zones for which data are available varied from 2.7 to 5.4 birds per acre (274 birds per 100 acres in northern Illinois and 539 in central Illinois, table 26). Principal breeding species in the habitat were the redwinged blackbird, meadowlarks, bobolink (northern zone), and dickcissel (central zone), table 26.

Vegetation of the sweet clover, taller than that of red clover, may be especially favorable to the redwinged blackbird, since this species appears to have attained considerably higher population densities in sweet clover. Population levels of the dickcissel were not so high in sweet clover

Table 24.—Summer avifauna in Illinois red clover fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE			CENTRAL ZONE				SOUTHERN ZONE		
	1909	1957	1958	1907	1909	1957	1958	1907	1957	1958
	(11)	(58)	(53)	(32)	(14)	(23)	(67)	(93)	(66)	(19)
*Redwinged blackbird.....	108	88	83	---	---	44	75	15	81	231
*Dickcissel.....	---	24	15	49	70	105	69	76	30	47
Common grackle.....	99	---	6	108	70	13	45	3	14	10
*Meadowlark (species?)....	9	19	40	6	42	30	54	40	59	16
House sparrow.....	---	7	15	28	14	158	15	9	---	10
Horned lark.....	---	---	9	---	---	35	118	1	---	---
Starling.....	---	20	---	---	---	---	131	---	---	---
Upland plover.....	108	7	---	---	7	9	13	---	---	---
*Grasshopper sparrow.....	27	5	4	18	21	22	4	11	3	---
Mourning dove.....	---	2	6	18	---	9	12	9	46	---
*Bobolink.....	18	50	25	---	---	---	---	---	---	---
Yellow-shafted flicker.....	45	---	2	6	21	---	---	1	---	---
Barn swallow.....	9	2	---	---	14	---	4	---	5	26
Brown thrasher.....	---	---	---	9	42	---	---	3	---	---
*Brown-headed cowbird.....	27	5	4	3	---	---	---	---	1	---
Vesper sparrow.....	9	24	4	---	---	---	---	---	1	---
Red-headed woodpecker.....	9	2	---	3	21	---	1	1	---	---
Robin.....	---	2	2	15	14	---	1	---	1	---
American goldfinch.....	---	---	2	---	---	---	1	---	---	31
Chimney swift.....	---	---	---	---	---	4	3	---	1	21
*Savannah sparrow.....	---	7	21	---	---	---	---	---	---	---
Eastern kingbird.....	9	---	4	6	---	---	---	2	5	---
Yellowthroat.....	---	---	---	---	---	---	---	---	---	26
Loggerhead shrike.....	---	---	---	---	21	---	---	1	---	---
Field sparrow.....	---	3	---	---	14	---	---	1	3	---
*Bobwhite.....	---	---	---	---	---	---	---	9	1	10
*Greater prairie chicken.....	---	---	---	---	14	---	---	---	---	---
Killdeer.....	---	2	6	3	---	---	3	---	---	---
*Ring-necked pheasant.....	---	7	---	---	---	4	1	---	---	---
Common crow.....	---	---	---	12	---	---	---	---	---	---
Eastern bluebird.....	9	---	---	---	---	---	---	---	1	---
Orchard oriole.....	---	---	---	3	---	---	---	---	5	---
Ruby-throated hummingbird.....	---	---	---	3	---	---	---	1	3	---
Song sparrow.....	---	5	---	---	---	---	1	---	---	---
Rough-winged swallow.....	---	---	---	---	---	---	4	---	---	---
Gray partridge.....	---	3	---	---	---	---	---	---	---	---
Blue jay.....	---	---	---	---	---	---	---	1	---	---
Baltimore oriole.....	---	---	---	---	---	---	---	---	1	---
Summer tanager.....	---	---	---	---	---	---	---	---	1	---
Indigo bunting.....	---	---	---	---	---	---	---	---	1	---
Unidentified bird.....	9	9	8	12	---	---	---	3	---	---
Total birds per 100 acres.....	495	293	256	302	385	433	555	187	263	428
Number of species.....	13	20	17	16	14	11	19	17	20	10

as in red clover; meadowlark populations were about the same in these two clovers.

Alfalfa Fields (Summer)

From about 18,000 acres in 1909, the area of Illinois land planted to alfalfa had increased to approximately 1,400,000 acres by 1957.

Alfalfa forms a cover 1-2 feet high, similar to that of red clover, though not quite so dense. The first cutting in Illinois is about half completed by mid-June and completed by early July. Second and third cuttings may be made in August and September. Most of the alfalfa fields we censused had mature stands.

Table 25.—Common birds (species making up approximately 85 per cent of birds counted) in red clover fields in the southern zone of Illinois, summers, 1907 and 1957.

1907	
Species	Per Cent
Dickcissel.....	41
Meadowlark (species?).....	23
Redwinged blackbird.....	8
Grasshopper sparrow.....	6
Mourning dove.....	5
House sparrow.....	5
Bobwhite.....	5
Total per cent.....	93*
Number of species.....	7*

1957	
Species	Per Cent
Redwinged blackbird.....	30
Meadowlark (species?).....	22
Mourning dove.....	17
Dickcissel.....	11
Common grackle.....	5
Total per cent.....	85
Number of species.....	5

* Five species made up 83 per cent of the birds counted. Seven species are included in this table because the last three had the same percentage.

All but 9 of the 237 acres of alfalfa censused were covered in 1957-1958; the largest samples represented northern Illinois.

Bird population densities in summer alfalfa fields varied from 2.1 to 4.2 birds per acre, large samples in northern Illinois indicating densities of 2.1-2.2 birds per acre, table 27. These populations were notably lower than those for other hay crops (mixed hay and the clovers), figs. 22-24. The difference may be attributed largely to the redwinged blackbird population, which attained notably higher densities in clover than in alfalfa fields. At least 30 species of birds were identified in alfalfa, table 28. In this habitat, the redwinged blackbird, eastern meadowlark, and dickcissel occurred in all zones in both 1957 and 1958. The breeding avifauna was almost the same as that recorded in red clover fields. Lists of common species

Table 26.—Summer avifauna in Illinois sweet clover fields (birds per 100 acres) as determined by strip censuses in two zones. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE		CENTRAL ZONE
	1957 (16)	1958 (10)	1958 (21)
*Redwinged blackbird.....	127	132	215
*Meadowlark (species?).....	38	41	57
*Dickcissel.....	13	....	86
House sparrow.....	70	....	5
Common grackle.....	....	51	24
Mourning dove.....	19	10	10
Horned lark.....	....	....	38
Chimney swift.....	....	....	29
Barn swallow.....	6	10	10
*Bobolink.....	25	....	....
Starling.....	19	....	....
Upland plover.....	....	....	10
Common crow.....	....	....	10
Brown thrasher.....	....	....	10
Robin.....	....	....	10
American goldfinch.....	....	10	....
Savannah sparrow.....	....	10	....
Field sparrow.....	....	....	10
Song sparrow.....	....	10	....
Brown-headed cowbird.....	6	....	....
Chipping sparrow.....	6	....	....
Lark sparrow.....	....	....	5
Unidentified bird.....	....	....	10
Total birds per 100 acres.....	329	274	539
Number of species.....	10	8	15

of birds in alfalfa and other types of hay in the northern zone are shown in table 29.

Marshland (Summer)

The amount of prairie marshland in the state of Illinois has been reduced since 1909 as the demand for tillable and urban land has increased. From data presented in a report of a U. S. Fish and Wildlife Service wetlands survey (Shaw & Fredine 1956:7, 20-5), we calculated that there were about 558,000 acres of prairie type marsh in Illinois in 1906 and only about 60,000 in 1950.

Table 27.—Statistical data on summer bird populations in Illinois alfalfa fields as determined by strip censuses in the three zones. Data are (1) from all alfalfa fields censused and (2) from sample areas (each 4 acres or more) in these fields.

ZONE AND YEAR	ALL ALFALFA FIELDS			SAMPLE AREAS					
	Acres	Birds Per Acre		Num- ber	Birds Per Acre (Breeding Species Only)				
		All Species	Breeding Species Only		Range	Mean	Standard Deviation	Standard Error	Mean ± 2 S.E.
Northern									
1957.....	75	2.2	1.5	7	0.2-4.4	1.5	1.4	0.5	0.5-2.5
1958.....	63	2.1	1.7	2	---	---	---	---	---
Central									
1957.....	28	4.2	1.1	3	0.9-4.7	2.5	---	---	---
Southern									
1958.....	40	2.1	1.2	5	0.5-1.7	1.1	0.4	0.2	0.7-1.5

Table 28.—Summer avifauna in Illinois alfalfa fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat.

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
	1957	1958	1957	1958	1957	1958
	(75)	(63)	(28)	(13)	(9)	(40)
*Redwinged blackbird.....	59	67	32	8	303	20
*Meadowlark (species?).....	49	37	21	23	22	75
Horned lark.....	16	6	165	---	---	5
*Dickcissel.....	1	2	32	23	76	28
Starling.....	8	---	25	99	---	---
House sparrow.....	3	3	77	---	22	5
*Grasshopper sparrow.....	4	3	28	68	---	---
*Bobolink.....	31	60	---	---	---	---
Barn swallow.....	7	2	18	---	---	48
Indigo bunting.....	---	---	3	---	22	---
Mourning dove.....	8	3	3	8	---	2
*Ring-necked pheasant.....	---	---	---	23	---	---
Upland plover.....	1	2	7	---	---	5
Vesper sparrow.....	8	3	3	---	---	---
Killdeer.....	1	2	---	---	---	10
Yellowthroat.....	---	---	---	---	11	---
*Brown-headed cowbird.....	3	---	---	8	---	---
Cardinal.....	---	---	---	---	11	---
*Savannah sparrow.....	4	5	---	---	---	---
Common grackle.....	5	---	---	---	---	2
*Bobwhite.....	3	---	---	---	---	---
Eastern kingbird.....	---	---	3	---	---	---
Brown thrasher.....	---	---	3	---	---	---
Robin.....	3	---	---	---	---	2
Chimney swift.....	---	---	---	---	---	---
Common crow.....	---	---	---	---	---	2
Swamp sparrow.....	---	2	---	---	---	---
Yellow-shafted flicker.....	1	---	---	---	---	---
American goldfinch.....	1	---	---	---	---	---
Field sparrow.....	1	---	---	---	---	---
Unidentified bird.....	3	9	---	---	---	5
Total birds per 100 acres.....	220	206	420	260	467	209
Number of species.....	21	14	14	8	7	12

Table 29.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in different types of hay crops in the northern zone of Illinois, summers, 1957 and 1958 (combined data).

MIXED HAY		RED CLOVER		ALFALFA	
Species	Per Cent	Species	Per Cent	Species	Per Cent
Redwinged blackbird.....	46	Redwinged blackbird.....	33	Redwinged blackbird.....	30
Bobolink.....	14	Bobolink.....	15	Bobolink.....	22
Meadowlark (species?)..	8	Meadowlark (species?)..	11	Meadowlark (species?)..	21
Common grackle.....	8	Dickcissel.....	8	Horned lark.....	5
Savannah sparrow.....	5	Vesper sparrow.....	6	Mourning dove.....	3
Brown-headed cowbird....	2	Savannah sparrow.....	5	Vesper sparrow.....	3
Mourning dove.....	2	House sparrow.....	4		
		Starling.....	4		
Total per cent.....	85	Total per cent.....	86	Total per cent.....	84
Number of species.....	7	Number of species.....	8	Number of species.....	6

The marshes censused for our report were low wetlands in pastures of north-eastern Illinois. Vegetation consisted of sedges and cattails at the margins of open water. Only small areas of this habitat were censused; the total area censused was 155 acres, most of it in the summers of 1957 and 1958, table 3.

The associated avifauna, as well as the marshland habitat, was distinctive: a very high bird population and a variety of species. In northern Illinois, the density of the bird population in marsh exceeded that in any other habitat but urban residential area. Marshland population densities varied from 4.9 to 7.4 birds per acre (488 birds per 100 acres in 1957 and 742 birds per 100 acres in 1909, table 30).

Despite the small acreage covered, at least 41 species of birds were identified in marshes, table 30. At least 18 of these nested in the habitat; three additional species, the bobolink and the two meadowlarks, probably nested at the dry margins of marshland.

Judged from the avifauna, the summer marsh habitat covered in 1909 was not strictly comparable to that censused in 1957-1958, though the commonest species for both periods were the redwinged blackbird and the grackle, table 30.

Shrub-Grown Areas (Summer)

Throughout Illinois, but especially in southern Illinois, there are small scattered tracts of shrub-grown grassland or "wasteland." The dominant features of the habi-

tat are deciduous shrubs under 10 feet in height and intermittent open areas of grass and weeds. In both surveys, this habitat was often found at the margins of woods. It was similar in some respects to fallow fields and pastures but differed from them in having a large amount of shrub cover. The acreage of this habitat was small compared to that of open-field areas and forest; only 267 acres of shrub-grown areas were censused, principally in 1957-1958 in southern Illinois. We estimated that there were about 500,000 acres of nonurban shrub-grown habitat in Illinois in 1907-1909 and in 1957-1958.

In terms of both numbers of birds and numbers of species, this was probably the richest summer habitat in the state, table 31.

Summer population densities for large samples (30 acres or more) of nonurban shrub-grown areas varied from 2.3 to 4.4 birds per acre (average: 3.4). We have insufficient data to determine whether there was a change in population density for this habitat in the half century following 1909.

At least 74 species of birds were identified in shrub-grown areas in summer, table 31; only 2, field sparrow and goldfinch, were found in all census years in all zones. Other species that occurred with high frequency were the indigo bunting, mourning dove, cowbird, cardinal, yellow-breasted chat, redwinged blackbird, grackle, towhee, brown thrasher, and catbird, tables 31-33.

In this habitat, the population density varied considerably from 1957 to 1958, table 31. That there was qualitative variation from zone to zone is shown in the lists of common birds, tables 32 and 33. In 1957-1958, the redwinged blackbird was the most numerous species in the northern zone, the field sparrow in the central zone,

and the indigo bunting in the southern zone.

Edge shrub habitat, such as fencerow and roadside, had very high bird populations. The 45 acres of this habitat censused in the state (all in 1957-1958) had a mean density of 22.3 birds per acre; 21.1 in the northern zone, 19.1 in the central,

Table 30.—Summer avifauna in northern Illinois marshland (birds per 100 acres) as determined by strip censuses. Figures in parentheses indicate numbers of acres censused; * indicates breeding species in this habitat. The acreage of marshland censused in the central and southern zones was too small to be included here.

SPECIES	1909 (19)	1957 (29)	1958 (58)
*Redwinged blackbird.....	494	162	226
*Common grackle.....	130	93	117
Bobolink.....	88	3	---
*Black tern.....	---	34	55
*Swamp sparrow.....	---	58	14
*Yellow-headed blackbird.....	---	---	65
Mourning dove.....	---	7	55
*Long-billed marsh wren.....	---	14	24
Song sparrow.....	5	10	10
Starling.....	---	21	2
Robin.....	5	---	15
*Blue-winged teal.....	---	---	19
Meadowlark (species?).....	10	---	9
*Killdeer.....	---	---	17
*Spotted sandpiper.....	---	7	10
Ring-necked pheasant.....	---	14	---
Savannah sparrow.....	5	7	---
*American bittern.....	---	10	---
*Least bittern.....	---	---	10
American goldfinch.....	---	10	---
Brown thrasher.....	---	7	2
*Brown-headed cowbird.....	---	7	2
*American coot.....	---	---	7
*Yellowthroat.....	---	3	3
Green heron.....	---	3	2
*Mallard.....	---	---	5
Yellow-billed cuckoo.....	5	---	---
Short-billed marsh wren.....	---	3	2
Horned grebe.....	---	---	3
Great blue heron.....	---	---	3
*Common snipe.....	---	3	---
Traill's flycatcher.....	---	3	---
Rough-winged swallow.....	---	3	---
Common crow.....	---	---	3
Eastern bluebird.....	---	3	---
Catbird.....	---	3	---
Black-crowned night heron.....	---	---	2
*King rail.....	---	---	2
*Virginia rail.....	---	---	2
Belted kingfisher.....	---	---	2
Tree swallow.....	---	---	2
Rail (species?).....	---	---	3
Unidentified bird.....	---	---	9
Total birds per 100 acres.....	742	488	702
Number of species.....	8	24	30

and 25.1 in the southern. This habitat was so limited in acreage (we estimated that there were about 86,000 acres of edge shrubbery in the state, most of it in southern Illinois) that it accounted for only a small part of the state population of birds.

Table 31.—Summer avifauna in Illinois shrub-grown areas as determined by strip censuses in the three zones (no edge shrub included in this table). Figures in parentheses indicate numbers of acres censused. Most of the species listed are known to nest in this habitat.

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE			
	1957 (15)	1958 (17)	1957 (15)	1958 (35)	1907 (17)	1909 (39)	1957 (67)	1958 (62)
Field sparrow.....	88	35	107	111	74	26	49	24
Indigo bunting.....	7	---	13	23	28	41	46	42
Redwinged blackbird.....	167	52	---	---	17	2	15	6
American goldfinch.....	47	46	53	23	23	28	1	10
Brown-headed cowbird.....	27	35	7	23	---	23	16	19
Cardinal.....	7	---	---	11	28	33	15	19
Brown thrasher.....	41	17	7	17	---	5	4	---
Yellow-breasted chat.....	---	---	13	11	6	33	27	8
Catbird.....	41	23	7	17	---	2	1	---
Song sparrow.....	41	35	---	11	---	---	---	---
Mourning dove.....	7	6	7	14	---	28	10	11
Yellowthroat.....	20	---	---	---	6	36	15	6
Common grackle.....	47	12	---	6	6	---	1	3
Savannah sparrow.....	60	---	---	---	---	---	---	---
Rufous-sided towhee.....	---	6	---	6	11	8	16	8
Red-headed woodpecker.....	---	---	7	3	---	36	---	---
Blue jay.....	---	---	---	9	17	13	4	1
Bank swallow.....	---	---	---	43	---	---	---	---
Chickadee (species?).....	7	6	---	11	---	---	16	---
Meadowlark (species?).....	14	23	---	---	---	2	---	---
Eastern kingbird.....	20	---	---	11	---	---	1	---
Tufted titmouse.....	---	---	---	6	---	8	18	---
Dickcissel.....	20	---	7	---	---	5	---	---
Yellow-billed cuckoo.....	7	---	---	---	11	10	1	1
Orchard oriole.....	---	---	---	3	---	13	6	8
Bobwhite.....	---	---	7	---	11	5	3	1
Carolina wren.....	---	---	---	---	6	10	7	3
Vesper sparrow.....	20	6	---	---	---	---	---	---
Robin.....	---	6	---	3	11	---	3	---
House wren.....	14	---	---	6	---	---	1	---
Traill's flycatcher.....	7	6	7	---	---	---	---	---
Eastern phoebe.....	7	---	---	---	---	8	---	3
Wood thrush.....	---	---	---	---	---	8	3	6
Great crested flycatcher.....	---	---	---	---	11	2	3	---
Eastern wood pewee.....	---	---	---	6	---	2	1	5
Gray partridge.....	14	---	---	---	---	---	---	---
Baltimore oriole.....	14	---	---	---	---	---	---	---
Starling.....	7	---	---	6	---	---	---	---
White-eyed vireo.....	---	---	---	---	6	2	4	1
American redstart.....	---	---	---	11	---	---	---	---
Bell's vireo.....	---	---	---	3	---	---	4	3
Prairie warbler.....	---	---	---	---	---	---	7	3
Ruby-throated hummingbird.....	---	---	---	3	---	5	---	1
Downy woodpecker.....	---	---	---	---	---	5	3	1
House sparrow.....	---	---	---	3	---	---	---	6
Red-bellied woodpecker.....	---	---	---	---	---	5	---	3
Common crow.....	---	---	---	---	---	8	---	---
Bewick's wren.....	---	---	---	---	6	2	---	---
Red-tailed hawk.....	---	---	7	---	---	---	---	---
Ring-necked pheasant.....	7	---	---	---	---	---	---	---

Table 31.—Continued

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE			
	1957 (15)	1958 (17)	1957 (15)	1958 (35)	1907 (17)	1909 (39)	1957 (67)	1958 (62)
Horned lark	7	---	---	---	---	---	---	---
Cliff swallow	7	---	---	---	---	---	---	---
Eastern bluebird	---	---	---	---	6	---	1	---
Yellow warbler	---	---	---	3	---	---	4	---
Bobolink	7	---	---	---	---	---	---	---
Grasshopper sparrow	7	---	---	---	---	---	---	---
Yellow-shafted flicker	---	6	---	---	---	---	---	---
Bachman's sparrow	---	---	---	---	6	---	---	---
Swamp sparrow	---	6	---	---	---	---	---	---
Sparrow hawk	---	---	---	---	---	5	---	---
Lark sparrow	---	---	---	3	---	2	---	---
Barn swallow	---	---	---	3	---	---	---	1
Mockingbird	---	---	---	3	---	---	1	---
Warbling vireo	---	---	---	---	---	---	4	---
Blue-gray gnatcatcher	---	---	---	---	---	---	---	3
Parula warbler	---	---	---	---	---	---	---	3
Kentucky warbler	---	---	---	---	---	---	3	---
Scarlet tanager	---	---	---	---	---	2	1	---
Chimney swift	---	---	---	---	---	---	1	1
Belted kingfisher	---	---	---	---	---	2	---	---
Whip-poor-will	---	---	---	---	---	---	1	---
Red-eyed vireo	---	---	---	---	---	---	1	---
Prothonotary warbler	---	---	---	---	---	---	---	1
Blue grosbeak	---	---	---	---	---	---	1	---
Unidentified bird	7	18	13	31	---	---	16	19
Total birds per 100 acres	793	344	262	443	290	425	335	230
Number of species	30	17	13	31	18	35	40	31

Table 32.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in shrub-grown areas in the southern zone of Illinois in four summers.

1907-1909		1957-1958	
Species	Per Cent	Species	Per Cent
Field sparrow	14	Indigo bunting	17
Indigo bunting	10	Field sparrow	14
Cardinal	8	Yellow-breasted chat	7
American goldfinch	7	Brown-headed cowbird	7
Yellowthroat	6	Cardinal	6
Yellow-breasted chat	5	Rufous-sided towhee	4
Red-headed woodpecker	5	Mourning dove	4
Blue jay	4	Yellowthroat	4
Mourning dove	4	Redwinged blackbird	4
Brown-headed cowbird	3	Tufted titmouse	3
Yellow-billed cuckoo	3	Carolina chickadee	3
Redwinged blackbird	3	Orchard oriole	3
Rufous-sided towhee	3	American goldfinch	2
Bobwhite	2	Carolina wren	2
Carolina wren	2	Prairie warbler	2
Great crested flycatcher	2	Wood thrush	2
Orchard oriole	2	Bell's vireo	1
Robin	1		
Total per cent	84	Total per cent	85
Number of species	18	Number of species	17

Table 33.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in shrub-grown areas in the northern and central zones of Illinois, summers, 1957–1958.

NORTHERN ZONE		CENTRAL ZONE	
Species	Per Cent	Species	Per Cent
Redwinged blackbird.....	20	Field sparrow.....	33
Field sparrow.....	11	American goldfinch.....	11
American goldfinch.....	8	Bank swallow.....	6
Song sparrow.....	7	Indigo bunting.....	5
Catbird.....	6	Brown-headed cowbird.....	4
Brown-headed cowbird.....	6	Catbird.....	4
Savannah sparrow.....	5	Brown thrasher.....	4
Common grackle.....	5	Yellow-breasted chat.....	4
Brown thrasher.....	5	Mourning dove.....	3
Meadowlark (species?).....	3	Eastern kingbird.....	2
Vesper sparrow.....	2	Chickadee (species?).....	2
Eastern kingbird.....	2	American redstart.....	2
Yellowthroat.....	2	Cardinal.....	2
Dickcissel.....	2	Song sparrow.....	2
<i>Total per cent</i>	<i>84</i>	<i>Total per cent</i>	<i>84</i>
Number of species.....	14	Number of species.....	14

A related edge habitat, the hedgerows, also had very high populations; for the 13 acres of this habitat censused in the state, the mean density was 23.2 birds per

acre. We estimated that there were about 13,000 acres of hedgerows in the state in 1958. Many acres of this valuable habitat for birds have been eliminated since then.



Fig. 20.—Orchard habitat in summer. The acreage of land in orchards declined greatly between 1909 and 1957. Because orchards comprise a habitat rich in both numbers and variety of birds, the acreage change represented a definite loss to the Illinois avifauna. The photograph was taken near Thompsonville, Franklin County, in southern Illinois, June 5, 1907, by Alfred O. Gross.

Orchards (Summer)

The total acreage of orchards in Illinois was reduced from about 300,000 acres in 1909 to about 31,000 in 1957.

This very uniform habitat is closely allied to shrubby areas. The orchards censused were mature or nearly mature pure stands, most of them of either apple or

Table 34.—Summer avifauna in Illinois orchards (birds per 100 acres) as determined by strip censuses in two zones. Figures in parentheses indicate numbers of acres censused. Most of the species listed are known to nest in this habitat. The acreage of orchards censused in some zones and years was too small to be included here.

SPECIES	NORTHERN ZONE	SOUTHERN ZONE			
	1958 (35)	1907 (19)	1909 (26)	1957 (8)	1958 (70)
House sparrow.....	---	159	19	50	66
Mourning dove.....	3	74	30	87	39
Field sparrow.....	17	53	64	62	19
Redwinged blackbird.....	---	5	---	137	19
Common grackle.....	3	63	---	---	57
American goldfinch.....	99	---	---	---	9
Orchard oriole.....	---	47	38	12	---
Robin.....	6	32	26	25	3
Catbird.....	6	16	35	25	---
Indigo bunting.....	14	11	11	25	11
Cardinal.....	---	11	15	12	21
Eastern meadowlark.....	---	16	19	12	9
Starling.....	---	---	---	25	31
Dickcissel.....	---	5	---	50	1
Blue jay.....	3	---	42	---	6
Brown thrasher.....	---	21	15	---	13
Mockingbird.....	---	11	23	12	1
Bobwhite.....	---	---	15	25	4
Yellowthroat.....	---	11	4	25	1
Bewick's wren.....	---	---	26	12	1
Tufted titmouse.....	---	11	15	---	1
Barn swallow.....	---	---	---	12	14
House wren.....	---	16	8	---	1
Yellow-shafted flicker.....	---	21	4	---	---
Chimney swift.....	14	5	---	---	1
Yellow-billed cuckoo.....	---	5	8	---	6
Eastern kingbird.....	---	11	4	---	4
Carolina chickadee.....	---	11	4	---	1
Yellow warbler.....	---	16	---	---	---
Rufous-sided towhee.....	---	---	11	---	4
Chipping sparrow.....	---	11	---	---	3
Carolina wren.....	---	11	11	---	---
Baltimore oriole.....	---	---	---	---	---
Song sparrow.....	11	---	---	---	---
Red-headed woodpecker.....	---	5	4	---	---
Great crested flycatcher.....	---	5	4	---	---
Loggerhead shrike.....	---	---	8	---	---
Common nighthawk.....	---	---	---	---	6
Eastern phoebe.....	---	---	---	---	6
Brown-headed cowbird.....	3	---	---	---	3
Acadian flycatcher.....	---	5	---	---	---
Common crow.....	---	---	4	---	---
Yellow-breasted chat.....	---	---	---	---	3
Vesper sparrow.....	3	---	---	---	---
Grasshopper sparrow.....	---	---	---	---	1
Unidentified bird.....	17	---	8	50	26
Total birds per 100 acres.....	199	668	475	658	391
Number of species.....	12	28	27	17	32

peach trees. Trees were 10-20 feet tall and equidistantly spaced in rows. The ground cover was bluegrass. A typical orchard censused in 1907 is shown in fig. 20. In the two study periods combined, 172 acres of orchard were censused, table 3, most of them in southern Illinois.

Orchards were shown to be excellent bird habitat, supporting high populations and a varied avifauna. In southern Illinois, summer bird populations in orchards were higher than in any other habitat except red clover and residential areas, fig. 24. Census data for the years with the largest acreages censused, 1909 and 1958, indicated populations of 3.9 and 4.7 birds per acre in the southern zone and 2.0 birds per acre in the northern zone (391, 475, and 199 birds per 100 acres, table 34).

At least 45 species of birds were identified in orchards, table 34, virtually all being potential nesters in this habitat. The mourning dove, field sparrow, robin, and indigo bunting were reported in both northern and southern Illinois in the summers for which census figures are available. In addition, in the southern zone, the house sparrow, cardinal, eastern meadowlark, mockingbird, and yellowthroat were listed in all census years.

Comparisons of bird populations of 1907-1909 with those of 1957-1958 are difficult to make because of the marked year-to-year variations and the small sizes of the samples, but there appears to be no real difference in total density of the orchard bird populations of the two periods. Population changes in some species occurred, however, table 35. An increase in population of the redwinged blackbird was apparent in this as in other habitats, and an increase in the barn swallow population in orchards was indicated. An observable decline occurred in orchard populations of a few species, particularly the orchard oriole, tufted titmouse, house wren, yellow-shafted flicker, Carolina chickadee, red-headed woodpecker, crested flycatcher, and eastern kingbird, tables 34 and 35.

Forests (Summer)

About 40 per cent of the land area of Illinois was originally forested, but three-fourths of this area has been cleared (King & Winters 1952:20-1). We estimated that there were about 3,500,000 acres of forest in Illinois in 1907-1909 and nearly 4,000,000 acres in 1957-1958. Most of the forest lies in southern Illinois.

Table 35.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in orchards in the southern zone of Illinois, summers, 1907-1909 and 1957-1958; + indicates approximately 0.5 per cent.

1907-1909		1957-1958	
Species	Per Cent	Species	Per Cent
House sparrow.....	16	House sparrow.....	16
Field sparrow.....	10+	Common grackle.....	13
Mourning dove.....	9	Mourning dove.....	11
Orchard oriole.....	7+	Starling.....	8
Common grackle.....	5+	Redwinged blackbird.....	8
Robin.....	5	Field sparrow.....	6
Catbird.....	4+	Cardinal.....	5
Blue jay.....	4	Barn swallow.....	4
Brown thrasher.....	3	Indigo bunting.....	3
Eastern meadowlark.....	3	Brown thrasher.....	3
Mockingbird.....	3	Eastern meadowlark.....	2
Tufted titmouse.....	2+	American goldfinch.....	2
Bewick's wren.....	2+	Bobwhite.....	2
Cardinal.....	2+	Dickcissel.....	2
Yellow-shafted flicker.....	2		
House wren.....	2		
Indigo bunting.....	2		
Yellow warbler.....	1+		
Total per cent.....	85	Total per cent.....	85
Number of species.....	18	Number of species.....	14

Table 36.—Statistical data on summer bird populations in Illinois forests with understory as determined by strip censuses in the three zones. Data are (1) from all such forests censused and (2) from sample areas (each 1 acre or more) in these forests.

ZONE AND YEAR	ALL FORESTS WITH UNDERSTORY CENSUSED		Number	SAMPLE AREAS				
				Birds Per Acre				
	Acres	Birds Per Acre		Observed Range	Mean	Standard Deviation	Standard Error	Mean $\pm$ 2 S.E.
Northern								
1957	66	2.2	6	0.6-5.7	2.2	1.9	0.8	0.6-3.8
1958	73	1.1	7	0.0-2.3	0.8	0.7	0.3	0.2-1.4
Central								
1907	4	3.3	2	---	2.6	---	---	---
1909	12	3.5	4	2.1-6.8	3.3	---	---	---
1957	90	2.2	7	0.4-3.2	1.7	0.9	0.3	1.1-2.3
1958	91	2.6	7	0.8-2.6	1.8	0.6	0.2	1.4-2.2
Southern								
1907	20	3.5	11	0.6-7.3	2.9	1.7	0.5	1.9-3.9
1909	40	4.1	8	2.9-7.3	4.0	1.1	0.4	3.2-4.8
1957	167	2.6	16	0.9-6.6	2.6	1.6	0.4	1.8-3.4
1958	157	2.2	12	0.9-3.4	2.1	0.7	0.2	1.7-2.5

Relatively little woodland was censused quantitatively in 1907-1909 (only 78 of the 809 acres censused in the two surveys, table 3). Because forest is such an important habitat for birds, in the summers of 1957 and 1958 we censused woodlands whenever our route crossed this habitat, even though the strip census is not well adapted to woodland areas. Most of the acreage we covered represented mature deciduous forest with understory; 85 acres of the woodland we censused lacked understory.

In southern Illinois, the forest was found to be a very rich habitat both in terms of species and numbers of birds, but, in northern and central Illinois, certain open-field habitats attained notably higher densities, figs. 22-24. As in other habitats, there were marked year-to-year differences in bird population densities in forest, tables 36 and 37. For woods with understory, the number of birds per acre for all regions and all summers in which censuses were made ranged from 1.1 to 4.1; the number of birds per acre in consecu-

Table 37.—Statistical data on summer bird populations in Illinois forests without understory as determined by strip censuses in the three zones. Data are (1) from all such forests censused and (2) from sample areas (each 1 acre or more) in these forests.

ZONE AND YEAR	ALL FORESTS WITHOUT UNDERSTORY CENSUSED		Number	SAMPLE AREAS	
				Birds Per Acre	
	Acres	Birds Per Acre		Observed Range	Mean
Northern					
1957	13	8.6	3	2.7-17.8	8.8
1958	25	1.4	5	0.0-2.5	1.2
Central					
1957	7	4.8	1	---	---
1958	26	2.8	4	1.2-3.4	2.2
Southern					
1957	7	3.0	2	---	3.0
1958	7	3.2	2	---	2.6

Table 38.—Summer avifauna in Illinois forests (birds per 100 acres) as determined by strip censuses in the three zones (forests with and forests without understory were included in the counts). Figures in parentheses indicate numbers of acres censused; data from the northern and central zones in 1907 and 1909 are too meager to be valid and they have not been included in this table. All stands included in this table were mature, natural deciduous forest typical of Illinois. Dense thickets of young saplings were not classified as forest. Most of the species of birds listed in this table are known to nest in forest.

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE			
	1957 (79)	1958 (98)	1957 (97)	1958 (117)	1907 (20)	1909 (40)	1957 (174)	1958 (166)
Cardinal	14	6	33	29	10	20	16	28
Tufted titmouse	1	---	25	16	35	5	17	21
Indigo bunting	5	4	7	9	35	25	21	10
Blue jay	5	7	8	17	30	38	3	2
Chickadee (species?)	16	15	13	8	---	---	12	11
Great crested flycatcher	---	3	8	5	20	28	5	1
Red-eyed vireo	14	11	7	3	5	8	8	7
Eastern wood pewee	9	6	9	10	5	10	8	3
Brown thrasher	3	---	2	10	30	15	---	---
Downy woodpecker	5	2	13	11	15	5	3	4
Common grackle	8	---	---	6	40	---	2	1
Field sparrow	---	1	1	4	---	40	7	2
Brown-headed cowbird	28	---	8	4	---	---	5	8
Robin	9	4	---	11	5	20	1	---
Rufous-sided towhee	4	---	1	4	15	10	9	5
Common crow	8	1	6	9	---	13	9	1
Wood thrush	1	1	---	1	20	13	3	6
Acadian flycatcher	1	---	5	---	---	5	17	12
Mourning dove	1	---	1	12	10	8	3	2
Yellow-shafted flicker	6	5	2	3	5	13	---	---
Red-headed woodpecker	1	6	3	6	5	13	---	---
American goldfinch	8	7	3	---	10	---	3	2
American redstart	---	1	19	5	---	---	3	2
Red-bellied woodpecker	---	---	4	5	5	5	6	4
Carolina wren	---	---	3	2	---	5	8	11
Blue-gray gnatcatcher	4	---	1	3	---	---	6	12
Yellowthroat	---	2	---	1	---	18	4	1
Yellow-breasted chat	---	---	1	---	5	15	3	2
Eastern bluebird	1	5	---	---	10	5	2	---
Kentucky warbler	---	---	---	4	---	---	8	11
Ovenbird	13	4	2	2	---	---	---	---
Catbird	3	2	2	12	---	---	1	---
House wren	4	1	4	10	---	---	---	---
Bobwhite	---	---	---	2	---	10	1	2
Sparrow hawk	---	---	---	---	15	---	---	---
White-eyed vireo	---	---	---	---	---	---	10	4
Summer tanager	---	---	---	---	5	---	5	4
Bewick's wren	---	---	---	---	---	13	---	---
Ruby-throated hummingbird	1	2	1	2	---	3	2	1
Hairy woodpecker	---	---	1	4	---	---	2	4
Prothonotary warbler	---	---	---	---	---	8	1	2
Red-tailed hawk	5	1	1	2	---	---	---	1
Song sparrow	3	1	3	---	---	---	3	---
Starling	10	---	---	---	---	---	---	---
Redwinged blackbird	5	2	---	---	---	---	1	1
Belted kingfisher	---	---	---	---	5	3	---	---
White-breasted nuthatch	1	1	---	2	---	---	2	1
Worm-eating warbler	---	---	---	---	---	---	6	1
Cerulean warbler	---	1	1	---	---	---	3	2
Yellow-billed cuckoo	---	---	2	---	---	3	---	1

Table 38.—Continued

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE			
	1957 (79)	1958 (98)	1957 (97)	1958 (117)	1907 (20)	1909 (40)	1957 (174)	1958 (166)
Barred owl	—	—	—	—	—	5	—	1
Yellow-throated vireo	—	—	1	—	—	—	3	2
Rose-breasted grosbeak	3	—	—	3	—	—	—	—
Scarlet tanager	3	—	—	—	—	—	1	1
Eastern kingbird	—	—	—	—	5	—	—	—
Orchard oriole	—	—	—	—	—	5	—	—
Warbling vireo	—	—	—	1	—	3	—	—
Parula warbler	—	—	—	—	—	—	2	2
Lark sparrow	—	—	—	1	—	3	—	—
Red-shouldered hawk	—	—	—	—	—	3	—	—
Ring-necked pheasant	3	—	—	—	—	—	—	—
Pileated woodpecker	—	—	—	—	—	—	2	1
Yellow warbler	—	—	2	—	—	—	1	—
Great horned owl	—	—	2	—	—	—	—	—
Hooded warbler	—	—	—	—	—	—	1	1
Baltimore oriole	1	—	—	1	—	—	—	—
Great blue heron	—	—	—	—	—	—	1	—
Common egret	—	—	—	—	—	—	—	1
Green heron	—	—	1	—	—	—	—	—
Turkey vulture	—	—	—	—	—	—	1	—
Cooper's hawk	—	1	—	—	—	—	—	—
Black-billed cuckoo	—	—	—	—	—	—	1	—
Whip-poor-will	—	—	—	—	—	—	1	—
Chimney swift	—	—	—	—	—	—	1	—
Eastern phoebe	—	—	—	—	—	—	—	1
Black and white warbler	—	—	—	—	—	—	—	1
Louisiana waterthrush	—	1	—	—	—	—	—	—
House sparrow	1	—	—	—	—	—	—	—
Meadowlark (species?)	—	1	—	—	—	—	—	—
Blue grosbeak	—	—	—	—	—	—	1	—
<i>Dendrocopos</i> (species?)	5	—	—	—	—	—	—	1
Hawk (species?)	—	—	—	—	—	—	1	—
<i>Caprimulgus</i> (species?)	—	—	1	—	—	—	—	—
Unidentified bird	9	10	11	16	5	13	16	20
Total birds per 100 acres	222	115	218	256	350	409	262	225
Number of species	37	30	38	38	24	34	52	47

tive census years in one zone (northern Illinois) ranged from 1.1 to 2.2, table 36.

In central Illinois, we found, population densities for woods with understory were 2.2 birds per acre in 1957 and 2.6 in 1958, table 36. Kendeigh and Kendeigh *et al.* (in *Audubon Field Notes* 1950–1960) presented data on the interior of a woodland in east-central Illinois showing that densities ranged from 151 to 275 territorial males per 100 acres in an 11-year period, 1950–1960. The population levels for all birds (both sexes) might have been twice as high. These data were from breeding-bird censuses. They sug-

gest that our strip census figures are low. Our counts may have included relatively few of the females in the population.

Bird populations in forest with understory in southern Illinois in all census summers ranged from 2.2 to 4.1 birds per acre, table 36. A southern Illinois forest with understory, censused in 1907, is shown in fig. 21. The population figures for both the central and southern zones were conspicuously higher in 1907–1909 than in 1957–1958. This situation is in marked contrast to the situation in open-field habitats, where highest populations were recorded in the later censuses. The acreage

Table 39.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in woodlands with understory in Illinois, summers, 1957 and 1958.

NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
Species	Per Cent	Species	Per Cent	Species	Per Cent
Chickadee (species?).....	15	Cardinal.....	14	Cardinal.....	10
Brown-headed cowbird.....	11	Tufted titmouse.....	11	Tufted titmouse.....	9
Red-eyed vireo.....	10	Blue jay.....	6	Indigo bunting.....	7
Cardinal.....	8	Downy woodpecker.....	5	Acadian flycatcher.....	7
Ovenbird.....	7	Chickadee (species?).....	5	Chickadee (species?).....	5
<i>Dendrocopos</i> (species?).....	5	Eastern wood pewee.....	4	Carolina wren.....	4
American goldfinch.....	5	Indigo bunting.....	4	Kentucky warbler.....	4
Eastern wood pewee.....	4	Mourning dove.....	4	Blue-gray gnatcatcher.....	4
Indigo bunting.....	3	Robin.....	3	Red-eyed vireo.....	3
Robin.....	3	Catbird.....	3	White-eyed vireo.....	3
Starling.....	2	American redstart.....	3	Rufous-sided towhee.....	3
Red-tailed hawk.....	2	Brown-headed cowbird.....	3	Brown-headed cowbird.....	3
Common crow.....	2	Great crested flycatcher.....	3	Eastern wood pewee.....	2
Blue jay.....	2	Brown thrasher.....	3	Wood thrush.....	2
Ruby-throated hummingbird.....	1	Red-bellied woodpecker.....	3	Field sparrow.....	2
Red-headed woodpecker.....	1	Red-headed woodpecker.....	2	Common crow.....	2
House wren.....	1	Common crow.....	2	Red-bellied woodpecker.....	2
Catbird.....	1	Red-eyed vireo.....	2	Summer tanager.....	2
Blue-gray gnatcatcher.....	1	Common grackle.....	2	Worm-eating warbler.....	2
		Hairy woodpecker.....	1	Downy woodpecker.....	2
		Rufous-sided towhee.....	1	Mourning dove.....	1
		Field sparrow.....	1	Cerulean warbler.....	1
				Yellow-throated vireo.....	1
				American goldfinch.....	1
				Blue jay.....	1
				American redstart.....	1
				Yellow-breasted chat.....	1
<i>Total per cent</i>	84	<i>Total per cent</i>	85	<i>Total per cent</i>	85
Number of species.....	19	Number of species.....	22	Number of species.....	27

Table 40.—Common birds (species making up approximately 85 per cent of birds counted) in woodlands in the northern zone of Illinois, summers, 1957 and 1958.

WOODLANDS WITH UNDERSTORY		WOODLANDS WITHOUT UNDERSTORY	
Species	Per Cent	Species	Per Cent
Chickadee (species?).....	15	Common grackle.....	48
Brown-headed cowbird.....	11	Yellow-shafted flicker.....	6
Red-eyed vireo.....	10	Blue jay.....	5
Cardinal.....	8	Eastern bluebird.....	4
Ovenbird.....	7	Eastern wood pewee.....	4
<i>Dendrocopos</i> (species?).....	5	Red-headed woodpecker.....	3
American goldfinch.....	5	Redwinged blackbird.....	3
Eastern wood pewee.....	4	American goldfinch.....	3
Indigo bunting.....	3	Robin.....	2
Robin.....	3	Common crow.....	2
Starling.....	2	Starling.....	2
Red-tailed hawk.....	2		
Common crow.....	2		
Blue jay.....	2		
Ruby-throated hummingbird.....	1		
Red-headed woodpecker.....	1		
House wren.....	1		
Catbird.....	1		
Blue-gray gnatcatcher.....	1		
<i>Total per cent</i>	84	<i>Total per cent</i>	82
Number of species.....	19	Number of species.....	11

of forest censused in 1907-1909 was so small that the figures derived may not be representative.

At least 80 species representing 27 families of birds were identified in forest (both with and without understory), table 38. The cardinal, indigo bunting, blue jay, red-eyed vireo, wood pewee, and downy woodpecker were recorded in all summers

and zones in which censuses were made. Other species for which the frequency of occurrence was very high were tufted titmouse, crow, crested flycatcher, towhee, mourning dove, and wood thrush. Indications of increases in forest populations between 1909 and 1957 were shown by the chickadees, blue-gray gnatcatcher, Kentucky warbler, and white-eyed vireo, table

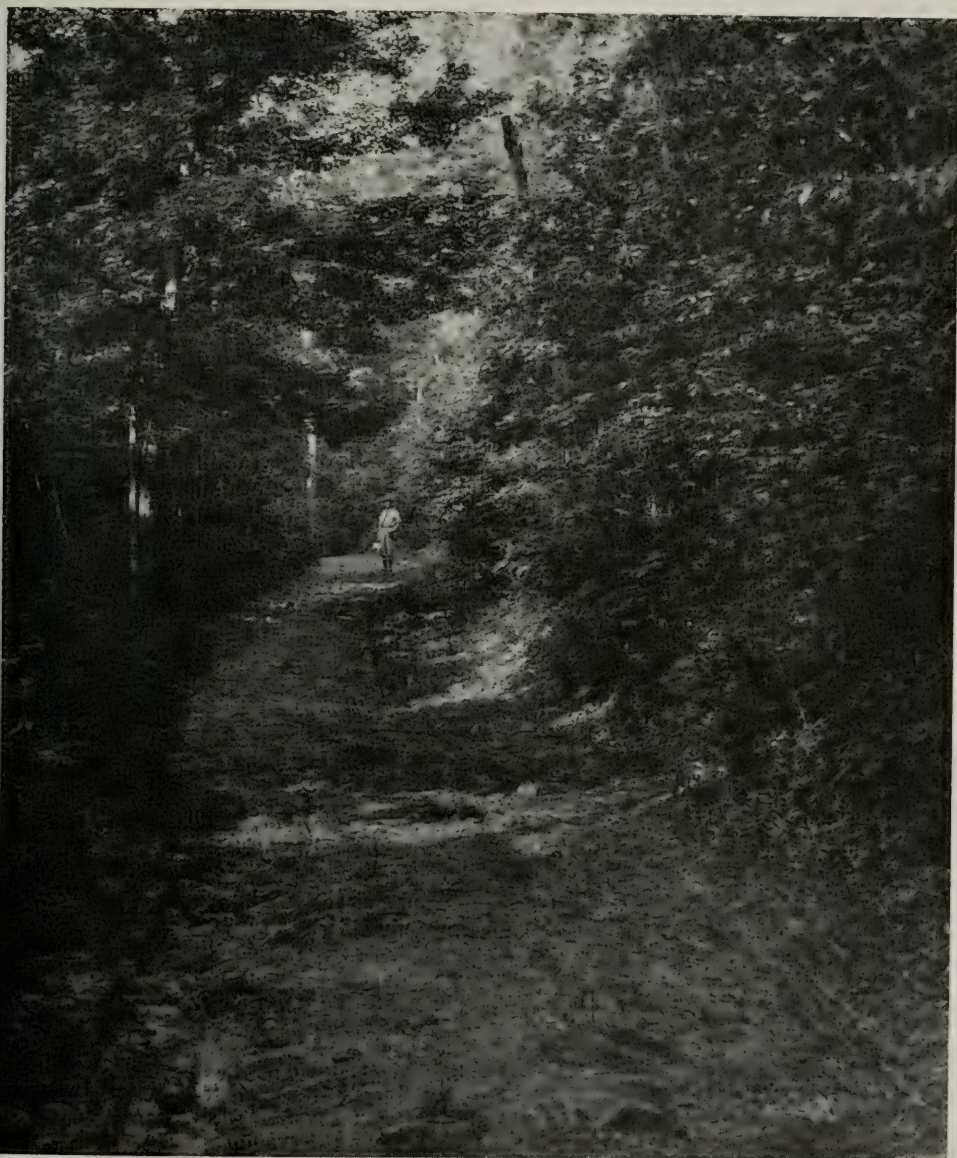


Fig. 21.—Forest with understory in southern Illinois censused in the summer of 1907. Such species as the summer tanager and wood thrush were recorded here. The photograph was taken east of Shetlerville, Hardin County, June 29, 1907, by Alfred O. Gross.

38. Species that showed some consistent marked population reduction between 1909 and 1957 were blue jay, crested flycatcher, wood thrush, brown thrasher, red-headed woodpecker, and yellow-shafted flicker.

Lists of common forest species (species comprising 85 per cent of the populations in forests with understory) in the three zones in the summers of 1957 and 1958 are presented in table 39. The forest avifauna was progressively more varied from northern to southern latitudes. The numbers of common species in the southern zone were about the same in 1907-1909 as in 1957-1958 in spite of the much larger area covered in the later censuses.

Though there were no consistent differences in density of bird populations between woods with understory and those lacking understory, tables 36 and 37, there

were qualitative differences, table 40. The avifauna of the forest without understory was less varied, and the species composition was different in that such shrub-nesting and ground-nesting species as the cardinal and ovenbird were scarce or lacking in forest without understory.

Urban Residential Areas (Summer)

The spread of urban residential areas began long before the first strip censuses reported here, but the acreage of land occupied by human residences and lawns increased greatly after 1909. We have estimated that acreage of this habitat climbed from about 350,000 acres in 1907 to 820,000 in 1957.

Only a small acreage of urban residential areas was censused in the summers of 1907-1909. In 1958, we made summer censuses in the residential areas of several

Table 41.—Summer avifauna in Illinois urban residential areas (birds per 100 acres) as determined by strip censuses in the three zones in 1958. Figures in parentheses indicate numbers of acres censused. Most of the species listed are known to nest in this habitat.

SPECIES	NORTHERN ZONE (160)	CENTRAL ZONE (75)	SOUTHERN ZONE (98)
House sparrow.....	435	378	271
Starling.....	121	119	180
Robin.....	132	109	102
Common grackle.....	96	27	22
Rock dove.....	69	40	38
Mourning dove.....	31	38	17
Purple martin.....	25	11	42
Chimney swift.....	14	27	24
Blue jay.....	16	16	21
House wren.....	17	13	16
Catbird.....	1	4	22
Cardinal.....	6	4	9
Yellow-shafted flicker.....	6	8	4
Brown thrasher.....	1	4	3
Great crested flycatcher.....	---	---	5
Tufted titmouse.....	---	---	5
Chipping sparrow.....	3	---	---
Eastern wood pewee.....	1	1	1
Red-headed woodpecker.....	---	---	2
Wood thrush.....	---	---	2
Warbling vireo.....	1	---	1
Downy woodpecker.....	1	---	---
Mockingbird.....	---	---	1
Carolina wren.....	---	---	1
Red-eyed vireo.....	1	---	---
Brown-headed cowbird.....	---	1	---
Rufous-sided towhee.....	---	---	1
Song sparrow.....	---	1	---
Unidentified bird.....	7	3	24
Total birds per 100 acres.....	984	804	814
Number of species.....	19	17	23

Table 42.—Common birds (species making up approximately 85 per cent of birds counted in strip censuses) in urban residential areas in the three zones of Illinois, summer, 1958.

NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE	
Species	Per Cent	Species	Per Cent	Species	Per Cent
House sparrow.....	44	House sparrow.....	47	House sparrow.....	34
Robin.....	13	Starling.....	15	Starling.....	23
Starling.....	12	Robin.....	13	Robin.....	13
Common grackle.....	10	Rock dove.....	5	Purple martin.....	5
Rock dove.....	7	Mourning dove.....	5	Rock dove.....	5
				Chimney swift.....	3
				Catbird.....	3
<i>Total per cent.....</i>	<i>86</i>	<i>Total per cent.....</i>	<i>85</i>	<i>Total per cent.....</i>	<i>86</i>
Number of common species.....	5	Number of common species.....	5	Number of common species.....	7
Total number of species.....	19	Total number of species.....	17	Total number of species.....	23

small cities in the three zones of the state; 333 acres of this habitat (yards adjacent to human dwellings) were censused in this year, table 3. As bird habitats, urban residential areas closely resemble open forest; they include some avifaunal elements of forest and shrub-grown areas.

The urban habitats censused in summer, rich in numbers of birds, had higher population densities than any other habitat except edge-shrub areas, figs. 22–24. Population densities in the urban habitats varied from 8.0 birds per acre in the central zone and 8.1 in the southern to 9.8 per acre in the northern zone (804, 814, and 984 birds per 100 acres, table 41).

A distinctive characteristic of the summer avifauna in this habitat was its constancy from zone to zone. The avifauna was not rich in numbers of species; only 28 were identified, table 41. Yet 15 species were reported in all three zones. In all other habitats, greater regional differences in the avifauna were apparent.

Though there were relatively few qualitative differences in the avifauna from zone to zone, population densities of several species showed interesting variation. A density cline was evident in the population of house sparrows, high in the north, much lower in the south. Other species with relatively high populations in the north were the robin, grackle, and rock dove. The starling and the catbird had their highest population densities in the southern zone.

The constancy of the avifauna from zone to zone was emphasized especially in the lists of common summer species, table 42. Five species in the northern and central zones and seven in the southern zone comprised 85 or 86 per cent of the total summer population in this habitat. Four common species, the house sparrow, starling, robin, and rock dove, were recorded in all zones in all census years. Three of these are introduced species that find optimum habitat in close proximity to man.

Comparison of Data for Summer Habitats

It can be seen from the foregoing that each habitat tends to have certain avifaunal associations. For some summer habitats, the avifauna is quite distinctive, and each habitat can be defined to a certain extent in terms of the qualitative and quantitative characteristics of its avifauna. For an understanding of the value of a given habitat, it is worthwhile to make direct comparisons of the avifaunal characteristics of this habitat with the characteristics of others. Comparative data on bird populations in different habitats in the three zones of the state are presented in figs. 22–24. For convenience in the following discussion, however, we have combined data for the three zones in order to have a single number represent each habitat. Unless otherwise stated, figures on population densities in different habitats represent all summer censuses (years

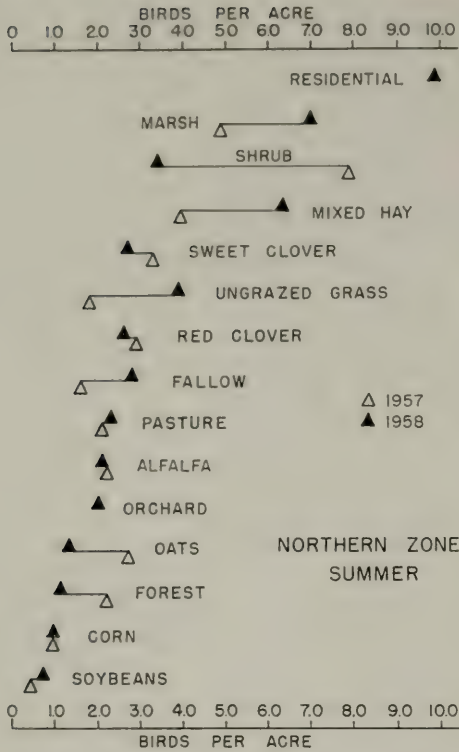


Fig. 22.—Densities of summer bird populations in a number of habitats in the northern zone of Illinois as determined by strip censuses in 1957 and 1958. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

and zones) combined and include all birds seen and all acreages censused.

Number of Birds.—Of the 17 major summer habitats censused in the various years and zones, the row crops of corn and soybeans consistently supported the lowest bird populations; they had an average density of about 0.6 bird per acre. Plowed ground, oats, and wheat were also poor habitats for birds; their average populations were 0.8, 0.8, and 0.9 bird per acre, respectively. Bird populations in oat fields showed marked increase between the 1909 and the 1957 censuses; populations were consistently low (0.6 bird per acre) in the early censuses, but relatively high in later years (1.7 birds per acre), primarily because of increases in the Icteridae. Populations in wheat fields showed no such change. Wheat, which is harvested earlier than oats, is a less attractive habitat.

Summer bird populations in grasslands and hay crops were variable, but usually conspicuously higher than in the bare-field, row-crop, and small-grain habitats. For these, the average bird population levels (birds per acre) for all censuses were as follows: fallow fields, 1.6; pasture, 1.7; ungrazed grassland, 2.2; mixed hay, 2.2; alfalfa, 2.5; red clover, 2.8; and sweet clover, 4.1.

Forests (all types) in summer supported populations of 2.4 birds per acre, about comparable to grasslands and hay habitats. The remaining habitats, shrub-grown areas (3.5 birds per acre), orchard (4.0), marsh (7.9), urban residential (8.9), and edge shrub (22.3), supported denser populations of birds.

In several habitats (plowed fields and row crops), the population of breeding species constituted only a relatively small part of the total population of these habitats in summer. Populations of breeding species were 0.2 bird per acre in corn and

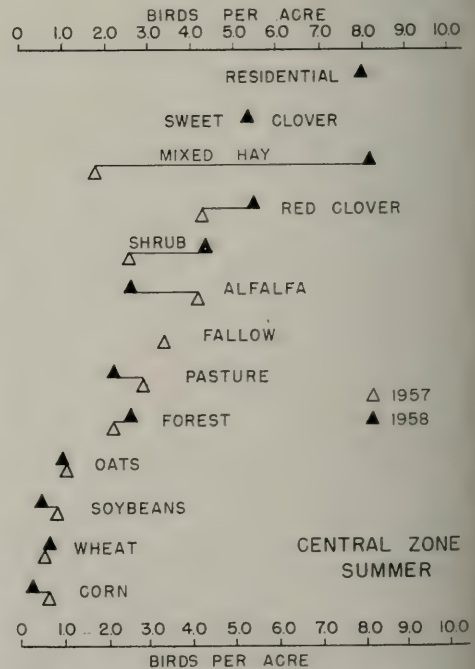


Fig. 23.—Densities of summer bird populations in a number of habitats in the central zone of Illinois as determined by strip censuses in 1957 and 1958. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

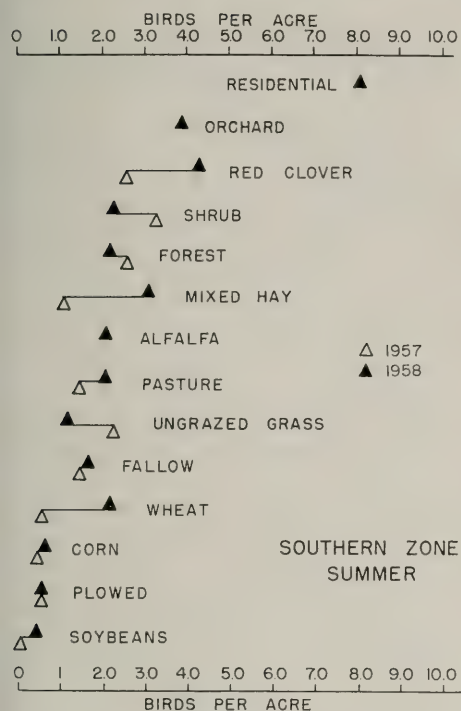


Fig. 24.—Densities of summer bird populations in a number of habitats in the southern zone of Illinois as determined by strip censuses in 1957 and 1958. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

0.4 bird per acre in plowed fields and soybeans.

In wheat, the populations of breeding species were 0.3 bird per acre. In oats, the level of the breeding population changed markedly from 1907–1909 (0.2 bird per acre) to 1957–1958 (1.1 birds per acre), and the average figure for the two census periods (0.4 bird per acre) has little meaning.

The grassland and related habitats had varied populations of breeding birds; 0.8 bird per acre in fallow fields and pastures and 1.5 birds per acre in ungrazed grass. The population levels in pasture, at least, showed some increase from 1907 to 1909 (from 0.5 to 0.7 bird per acre) to 1957 to 1959 (from 0.9 to 1.4 birds per acre).

Ungrazed grasslands had notably higher summer populations than other grass habitats and higher proportions of breeding birds relative to the total populations.

Breeding-bird populations in hay crops were less varied qualitatively but higher quantitatively than those in grassland. The numbers of birds per acre were 1.5 in mixed hay, 1.7 in alfalfa, 1.9 in red clover, and 2.8 in sweet clover (small sample). Breeding-bird populations in hayfields increased markedly during the half century following 1909.

Virtually all of the species recorded in summer for forests and urban residential areas were potential breeders or nesters in these habitats. Populations of breeding species were, for forests, 2.4 birds per acre; orchards, 3.3; shrub-grown areas, 3.5; marshes, 5.5; and urban residential areas, 8.9.

Number of Species.—The censused habitats that supported the greatest numbers of birds in summer did not necessarily support the most varied avifaunas. However, the row-crop and bare-field habitats (corn, soybeans, and plowed ground) that had low populations in terms of birds per acre were also low in numbers of species. In these habitats, only the horned lark occurred regularly as a nesting species, tables 5 and 7.

In small-grain fields, the total nesting avifauna, which included at least 10 species, was much more varied than that in row crops, tables 10 and 12.

Even more varied was the avifauna of grasslands and fallow fields, which supported at least 20 species of breeding birds, tables 14, 15, and 17. The avifauna in hay crops was less varied than that in grasslands. The 14 species of birds breeding in hayfields were grassland species that tolerated or even preferred the tall, dense hay cover, tables 19, 24, 26, and 28.

The marshland avifauna in northern Illinois was rich in number of species, and at least 18 of the 41 or more species in the marsh habitats in summer were nesters, table 30; this habitat was similar to grasslands and fallow fields in number of breeding species, but the marshland avifauna was much more specialized.

The woody habitats (shrub areas, orchard, and forest) were the richest of the summer habitats in numbers of species, tables 31, 34, and 38. About 40 of the 74 or more species of birds found in shrub-grown land probably nested in this habitat; in orchards, 37 of the 45 or more spe-

cies recorded were probably nesters; and virtually all of the 80 or more species found in forest probably nested there.

Residential areas, though a woody habitat, had a much more restricted summer avifauna, with 28 species, table 41, probably all of them nesting in this habitat.

In two habitats that were roughly similar, the population density tended to be higher in the habitat in which the avifauna-habitat relationship was more specialized and the avifauna was less varied. For example, residential areas, which had a more specialized avifauna-habitat relationship and a less varied avifauna than forests, had consistently higher population densities.

Statewide Summer Populations

A factor that must be considered in evaluating a particular habitat for birds is its total acreage. For instance, though ungrazed grasslands support a relatively high population of birds per unit of area, this high population density has little effect on the state population because of the very limited acreage of the habitat.

Extrapolating from the crop acreages presented by the Illinois Co-operative Crop Reporting Service (Ewing 1959), the U. S. Bureau of the Census (1913, 1961), and our census data, we can roughly estimate the total number of birds in a given habitat and also the total number of birds in the state for the summers of 1909, 1957, and 1958 (no data for northern zone in 1907).

Illinois has a total land area of about 35,800,000 acres. Ironically, the largest single habitat type in the state (row crops, principally corn and soybeans) is also one of the poorest of the bird habitats. If the censuses show the true distribution of birds in the various habitats of the state at given times, then in the summer of 1909 there were about 6,376,000 birds in the row crops (10,483,000 acres): corn (10,173,000 acres) and garden vegetables (310,000). By 1957, the land in corn (all types) had been reduced to about 8,280,000 acres, but another row crop, soybeans, had come into prominence and amounted to 4,979,000 acres, while garden vegetables accounted for only 70,300 acres. The total area of row-crop habitat was thus increased by nearly 3,000,000 acres over the

1909 acreage. In 1957, the total population of birds in this habitat was estimated to be 8,170,000, an increase of about 1,790,000 over the 1909 population.

The importance of the row-crop and plowed-field habitats as feeding grounds for birds is difficult to evaluate. The ultimate appraisal should be in terms of species survival, which is closely associated with nesting opportunity; in this frame of reference, the row crops have relatively little importance to the total avifauna. The expansion of row crops at the expense of other habitats represents a loss in both variety and numbers of birds.

Small grain crops in Illinois have decreased in acreage since 1909, when there were about 4,235,000 acres of oats (plus rye) and the summer population in this habitat was estimated to be about 2,955,000 birds. In 1957, there were 2,990,000 acres of oats (plus rye) in Illinois; despite the decrease in acreage, the bird population in the habitat was estimated to be even higher than in 1909 (5,552,000) because of an increase in population density in the habitat, particularly among the Icteridae in the northern half of the state. The acreage of wheat (plus barley) decreased from 2,250,000 in 1909 to 1,960,000 in 1957; the bird population in this habitat also decreased (1909: 1,494,000; 1957: 1,121,000).

By our estimate, the area of ungrazed grassland in Illinois decreased from about 331,000 acres in 1909 to 218,000 in 1957, and the state bird populations in this habitat from 612,000 birds in 1909 to 464,000 in 1957.

We estimated that fallow fields in the state occupied 1,496,000 acres in 1909 and 1,034,000 in 1957; our estimates of the populations in this habitat were 2,244,000 birds in 1909 and 1,663,000 in 1957.

In 1909, there were in Illinois about 6,085,000 acres of nonwoodland sod pasture that contained a summer population estimated at 11,650,000 birds. In 1957, though over 2,000,000 acres of hay and other crops were used for pasture, sod pastureland amounted to only 1,965,000 acres; the bird population in this habitat was estimated to be 4,139,000, 7,500,000 below the 1909 population. Not all of the reduction represented breeding birds; if we consider breeding species only, the esti-

mated number of birds in Illinois pastures decreased from 4,800,000 in 1909 to 2,160,000 in 1957.

Coincidental with the loss in acreage of grassland, there was an increased use of cultivated hay plants for pasture in Illinois, and, in recent years, increased acreage of soil improvement (soil bank) hay. Thus, while the acreage of hay plants for harvest declined from 3,349,000 acres in 1909 to 2,459,000 acres in 1957, the total acreage of hay plants for all purposes was 5,254,000 acres in 1957, an increase of 1,905,000 acres over the 1909 acreage. In the same period, there was some change in the types of hay produced. Alfalfa had a negligible acreage (18,000 acres) in 1909, but it had become a leading hay crop (1,424,000 acres) by 1957. Timothy, on the other hand, was planted on 1,870,000 acres in 1909, while in 1957 there was very little acreage of pure timothy. In 1909, timothy and mixed hay had about the same qualitative-quantitative avifaunal characteristics, and for final tabulation we lumped the census data for these crops. In all summer hay crops combined, the total summer population was estimated to be 6,834,000 birds in 1909 and 12,930,000 in 1957. For the most part, the increase represented increased acreage, for population densities in this habitat were similar over most of the state in 1909 and 1957. To some extent, the increase in hayfield acreage replaced the lost acreage in pastureland, but the gain in the hayfield bird population compensated for the loss in the pastureland population only in numbers of birds, not in variety of birds.

The amount of prairie (nonwood, non-shrub) marshland in Illinois decreased from about 558,000 acres in 1909 to about 60,000 acres in 1957. The estimated total bird population for this rich habitat was 4,140,000 in 1909 and 293,000 in 1957. These figures represent an estimated loss of 3,847,000 birds in the population and, even more important, a loss in faunal variety. The marsh avifauna is highly varied and highly specialized, and most of the marsh species cannot survive in another habitat.

Based on our census data, the acreage of shrub-grown areas in 1909 (469,000 acres) was close to that in 1957 (507,000 acres). Despite the limited acreage, esti-

mated summer bird populations were high in shrub-grown habitat: 1,993,000 birds in 1909 and 1,892,000 in 1957.

In 1909, there were about 301,000 acres of Illinois orchards with an estimated summer population of 1,422,000 birds. By 1957, when orchards had been reduced to about 31,000 acres, the estimated summer population (108,000 birds) in this habitat was negligible by comparison with the 1909 level. Though most species of orchard birds can survive in other habitats (shrub-grown areas and forest or woodlands), the loss is still regrettable. Probably much of this high-density habitat, which supported a varied avifauna, was replaced by poor-habitat crops, such as soybeans.

Forest or woodland acreage was probably greater in 1957 than in 1909, when there were, by our estimates, about 3,459,000 acres with a statewide summer population of 14,149,000 birds. In 1957, forests covered 3,996,000 acres, but the statewide population of birds (9,886,000) was estimated to be less (by 4,261,000) than in 1909, because population densities in forests tended to be lower in the later years.

Acreages for urban residential areas in Illinois are not available for 1909, but on the basis of the urban (human) population and acreage data for urban areas in later years, we estimate that there were about 350,000 acres of urban areas in Illinois in 1909. If the 1909 and 1957 bird population densities in this habitat were comparable to the 1958 level, when censuses were made, then the estimated summer population in 1909 was about 3,269,000 birds. By 1960, the acreage of urban areas had increased to about 820,000 acres and the bird population to about 7,657,000.

Commercial sections of urban areas have much smaller bird populations than residential sections. Virtually no native species are found in commercial areas; the avifauna of these areas consists almost entirely of the three introduced species (house sparrow, starling, and rock dove). Urban residential areas represent a modified forest habitat that can be an important reservoir for several species of native birds.

For all of the habitats mentioned, our estimates of the total statewide popula-

tions of adult birds in summer were 57,138,000 in 1909 and 53,875,000 in 1957. These data accounted for 33,368,000 acres in 1909 and 32,290,000 in 1957, leaving some of the acreage for the state unaccounted for: about 2,499,000 acres in 1909 and 3,505,000 in 1957. In 1957, about 1,289,000 acres of land (excluding urban areas) were covered by the concrete, asphalt, or gravel of the state or federal highways and 14,000 additional acres were covered by railroad tracks and ties. Some road surfaces (especially gravel) may be of some value to birds, but, if we appraise in terms of species survival, road surfaces must be considered a void in the statewide acreage of bird habitats. Even after the acreage of these areas was included, there were still about 2,202,000 acres unaccounted for in 1957. Some of this acreage undoubtedly represented good bird habitats, such as cemeteries, grassy roadsides, and sod airfields, while part of it must have represented poor habitats, such as extrarurban factories, other rural buildings, and paved airport runways. Included among the high-density habitats, as yet unaccounted for, were edge shrubs (estimated acreage in 1957: 86,000; estimated bird population in 1957: 1,918,000) and hedgerows (estimated acreage in 1957: 13,000; estimated bird population in 1957: 172,000); we lack comparative data on these habitats for 1909.

If our estimates are reasonably close to the actual numbers, there was little change in the total number of summer bird residents in the state between 1909 and 1957. If the acreage unaccounted for in 1909 and 1957 had harbored bird populations comparable to those in the acreage accounted for, then Illinois would have had state bird populations of about 61,333,000 birds (mean density for state, 1.71 birds per acre) in 1909 and 59,778,000 birds (mean density for state, 1.67 birds per acre) in 1957. One possible explanation of the closeness of the 1909 and the 1957 populations is that the state land area has a saturation population level of about 60,000,000 birds in summer and that this saturation level had been reached at least as early as 1909. There is a limit to the mass of protoplasm that can be supported on a given land area. This mass

of protoplasm could be expressed in terms of numbers of birds (and other animals) per unit area. It seems unlikely that the number of birds on a land area the size of Illinois would remain constant from year to year through the decades, even if a saturation level had been reached. Too many interdependent factors are involved—including the varied nature of the avifauna itself.

To obtain data on year-to-year variations in the statewide bird population, we estimated the 1958 population, as well as the 1909 and 1957 populations; no data are available for the northern zone in 1907, and we did not estimate the state population for that year. In the summer of 1958, we estimated, there were 60,244,000 birds on 32,806,000 acres of Illinois land (1.84 birds per acre), or, for the total acreage in the state, about 65,586,000 birds, about 5,600,000 more than in 1957.

The 1957 and 1958 summer populations showed that the number of birds in the state may vary appreciably from one year to another even though the acreages of each habitat remain about the same. Appreciable variations in bird populations are to be expected. The population in one year depends on productivity in the previous year and on survival of birds in migration and on the wintering grounds. Because weather is variable, productivity (therefore population) may vary greatly from year to year, as well as from habitat to habitat and from zone to zone. For 1957 and 1958, our estimates of bird populations in Illinois cornfields were, respectively, 5,705,000 and 5,397,000 birds. In the same period, the number of birds in oat fields changed drastically (1957: 5,552,000; 1958: 3,276,000). While the bird population in oat fields decreased, the population in wheat fields increased from 1957 to 1958 (from 1,121,000 to 2,459,000). Both of these changes may have represented the same phenomenon, that is, a habitat shift by birds from one type of grain field to another.

Mean population densities varied somewhat from zone to zone. The northern zone consistently had the highest average density in summer. Mean densities in the summer (June) of 1909 were 2.0 birds per acre for the northern zone (2.5 in 1957, 2.4 in 1958); 1.4 for the central

zone (1.4 in 1957, 1.7 in 1958); and 1.7 for the southern zone (1.4 in 1957, 1.7 in 1958). To some extent this variation reflects the lack of uniformity in distribution of such high-density habitats as urban residential areas, marsh, and forest. The relatively low mean density for the southern zone is surprising in view of the large acreage of forest in this zone.

The gross figures for the statewide summer population of birds include many species of birds, all of which have fluctuating populations. Population increases in one species might cancel decreases in another species. It is pointless to speculate further on the meaning of the gross changes until we have considered the individual species in more detail.

One generalization can be made here: that among the habitats considered—some primarily natural (prairie, forest, marsh) and some cultivated (corn and soybeans)—the 1909 summer bird populations tended to be higher in the natural habitats and the 1957 populations higher in the cultivated habitats.

BIRD POPULATIONS IN WINTER HABITATS

Bird populations in winter are much more variable than in summer, and comparison of results of the two sets of censuses as an index to long-term changes in the avifauna is somewhat tenuous.

During the winter season (December 1–February 15), 10,180 acres of Illinois land were censused, 5,299 acres in 1906–07 and 4,881 in 1956–57 and 1957–58. The acreages of each habitat covered in different regions and different winters are shown in table 43. The habitats in order of descending acreage were corn, pasture, small grain stubble, wheat, hayfield, forest, plowed ground, soybean stubble, fallow land, shrub-grown area, orchard, and marsh. The acreages of orchard and marsh were so small that we did not calculate the bird populations in them. The bird populations for the other types of habitat are discussed below. A comparison of bird population densities in various habitats is shown in figs. 25–27.

Cornfields (Winter)

The methods of corn harvesting have changed considerably since the first winter survey by Gross and Ray. Hand-picked fields, which comprised most of the cornfield acreage in the winter of 1906–07, were characterized by the tall cover of the standing stalks and by little grain left in the fields. Fields in which the stalks were cut offered little cover (except where there were shocks) and in this respect bore some resemblance to modern harvested fields. However, none of the early cornfield types was strictly comparable as a winter habitat to the cornfields of today. Mechanical

Table 43.—Acreages of habitats covered in winter strip censuses in the three zones of Illinois, 1906–07, 1956–57, and 1957–58.

TYPE OF HABITAT	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE		TOTAL
	1906–07	1956–57	1906–07	1956–57	1906–07	1956–57	
		1957–58		1957–58		1957–58	
All corn	734	329	516	759	281	277	2,899
Pasture	440	109	371	156	181	93	1,350
Small grain stubble	223	192	280	268	162	124	1,249
Wheat	57	21	249	237	289	293	1,146
Hayfield	172	182	164	180	90	85	873
Forest	65	45	50	152	241	211	764
Plowed ground	269	68	125	86	18	93	659
Soybean stubble	—	28	—	322	21*	126	497
Fallow field	59	45	34	79	114	103	434
Shrub area	18	13	—	74	33	101	239
Orchard	3	3	19	1	18	7	51
Marsh	—	7	—	4	—	8	19
Total	2,041	1,042	1,808	2,318	1,450	1,521	10,180

* Some or all of this acreage may have been field bean or navy bean stubble.

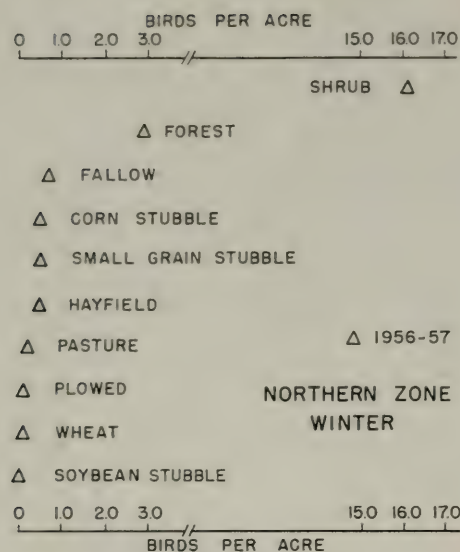


Fig. 25.—Densities of winter bird populations in a number of habitats in the northern zone of Illinois as determined by strip censuses in 1956-57. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

picking of the grain leaves broken-over stalks and scattered grain throughout the fields. Modern cornfields in winter offer relatively little concealing or protective cover, but a considerable amount of food for some species of birds.

Of 2,896 acres of cornfields censused for birds in winter (all years), 1,184 acres represented fields that had been hand picked (1906-07), 254 acres were of fields from which the stalks had been cut and removed (1906-07), 93 acres had had the corn cut and shocked (1906-07), and 1,365 acres were of mechanically picked cornfields (1956-57 and 1957-58), tables 44 and 45.

In the various types of cornfields, in all census years, winter bird populations tended to be most dense and most varied in the southern zone of the state, least dense and least varied in the northern zone, tables 44 and 45. Two types of cornfield habitats, hand-picked (standing cornstalk) fields in 1906-07 and mechanically picked fields in 1956-57 and 1957-58, were especially important because each type occupied most of the corn acreage in its period.

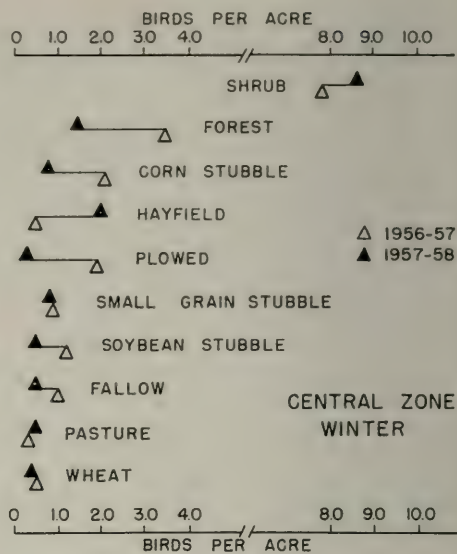


Fig. 26.—Densities of winter bird populations in a number of habitats in the central zone of Illinois as determined by strip censuses in 1956-57 and 1957-58. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

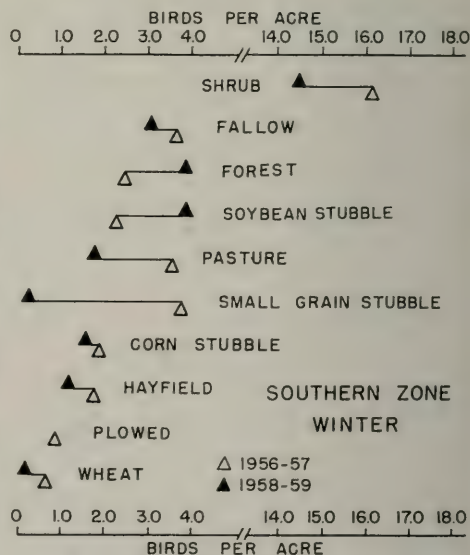


Fig. 27.—Densities of winter bird populations in a number of habitats in the southern zone of Illinois as determined by strip censuses in 1956-57 and 1957-58. The point of each triangle indicates the mean number of birds per acre for all fields of the habitat censused in the year and zone specified.

The term *shrub* in figs. 25-27 includes both shrub-grown areas and edge shrub.

Quantitatively, bird populations in the two types were similar. Bird populations in hand-picked cornfields in the winter of 1906-07 (most of the censuses were in January) were 0.2 bird per acre (22 birds per 100 acres) in the northern zone, 1.4 birds per acre (138 birds per 100 acres) in the central zone, and 2.0 birds per acre (203 birds per 100 acres) in the southern zone, table 44. Bird populations in mechanically picked cornfields in the winter of 1956-57 (most of the censuses were in January) were 0.5 bird per acre (50 birds per 100 acres) in the northern zone, 2.1 birds per acre (207 birds per 100

acres) in the central zone, and 1.9 birds per acre (188 birds per 100 acres) in the southern zone, table 45.

Qualitatively, there were some important differences between the two periods with respect to the winter bird populations of cornfields. The winter avifauna of hand-picked fields (1906-07) was composed more of species that we usually think of as shrub or forest-edge inhabitants, while the winter avifauna of mechanically picked fields contained more prairie or open-field species, such as the horned lark and Lapland longspur. The taller cover of hand-picked fields (1906-07) was of

Table 44.—Winter avifauna in Illinois cornfields of different types (birds per 100 acres) as determined by strip censuses in the three zones in 1906-07. In the first type, the ears have been picked and the stalks left standing; in the second, the stalks have been cut and shocked; in the third, the stalks have been cut and removed, leaving only short stubble. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	Ears Picked (602)	Stalks Cut and Shocked (42)	Stalks Cut and Re-moved (90)	Ears Picked (360)	Stalks Cut and Shocked (49)	Stalks Cut and Re-moved (107)	Ears Picked (222)	Stalks Cut and Shocked (2)	Stalks Cut and Re-moved (57)
Common crow.....	3	---	---	125	22	---	4	---	10
Slate-colored junco.....	---	---	---	9	---	---	51	---	47
Tree sparrow.....	1	---	5	1	---	11	2	---	40
Meadowlark (species?).....	---	---	---	---	---	---	59	---	5
Cardinal.....	---	---	---	---	38	1	3	---	7
Mourning dove.....	1	---	---	+	---	---	36	---	---
Chickadee (species?).....	+	---	---	+	4	2	3	---	14
House sparrow.....	7	---	---	1	16	---	1	---	2
Bobwhite.....	+	---	---	---	---	7	16	---	---
American goldfinch.....	9	---	4	---	---	---	1	---	---
Yellow-shafted flicker.....	---	---	---	---	---	---	8	---	2
Song sparrow.....	---	---	---	+	---	---	3	---	5
Horned lark.....	---	---	---	+	4	2	1	---	---
Sparrow hawk.....	---	---	---	---	4	1	+	---	2
Downy woodpecker.....	+	---	---	---	---	---	1	---	5
Eastern bluebird.....	---	---	---	---	---	---	3	---	3
Carolina wren.....	---	---	---	---	---	---	---	---	5
White-throated sparrow.....	---	---	---	---	---	---	4	---	---
Blue jay.....	+	---	---	---	2	---	1	---	---
Red-bellied woodpecker.....	---	---	---	---	---	---	+	---	3
Tufted titmouse.....	---	---	---	---	---	---	---	---	2
Turkey vulture.....	---	---	---	---	---	---	1	---	---
Robin.....	---	---	---	---	---	---	1	---	---
Fox sparrow.....	---	---	---	---	---	---	1	---	---
Rough-legged hawk.....	+	---	---	---	---	---	---	---	---
Red-headed woodpecker.....	---	---	---	---	---	---	+	---	---
Mockingbird.....	---	---	---	---	---	---	+	---	---
Loggerhead shrike.....	---	---	---	+	---	---	---	---	---
White-breasted nuthatch.....	---	---	---	---	---	---	+	---	---
Hawk (species?).....	---	---	---	+	2	---	+	---	---
Total birds per 100 acres.....	22	---	9	138	92	24	203	---	152
Number of species.....	10	---	2	10	8	6	26	---	15

no value to these open-field birds, and they were surely favored by the habitat changes that came with mechanical harvesting. In 1906-07, the cut fields, which should presumably have been good habitat for the lark, had poor populations of these species. The winter data, like the data for summer, indicate that the lark population increased greatly between 1906-07 and 1956-57.

In cornfields of all types combined, at least 38 species of birds were found in the winter census transects, tables 44 and 45. As already indicated, the cornfield avifauna was an interesting combination of prairie and shrub or forest-edge species, the shrub species being particularly prom-

inent in southern Illinois and in the hand-picked fields of the first survey. For most of the winter birds, cornfields must be a marginal foraging habitat, for few species were found with great regularity in these fields. The tree sparrow was recorded in cornfields in all years and all zones except the northern zone in 1957-58 (in mechanically picked cornfields). Other important species of this winter habitat, from the standpoint of numbers of individuals seen or frequency of sightings, were the crow, junco (southern zone), and meadowlarks (southern zone) in most types of cornfields; the mourning dove, bobwhite, and chickadees in hand-picked cornfields; and the Lapland longspur and

Table 45.—Winter avifauna in Illinois harvested cornfields (birds per 100 acres) as determined strip censuses in the three zones. The 1906-07 figures are for fields in which cornstalks had been cut by hand; figures for the other years are for fields mechanically picked. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (90)	1956-57 (308)	1957-58 (21)	1906-07 (107)	1956-57 (491)	1957-58 (268)	1906-07 (60)	1956-57 (154)	1957-58 (123)
horned lark	---	14	9	2	90	24	---	25	15
late-colored junco	---	---	---	---	---	---	47	26	94
Lapland longspur	---	18	---	---	107	42	---	---	---
tree sparrow	5	9	---	11	6	+	40	3	2
red-winged blackbird	---	---	---	---	---	---	---	57	---
meadowlark (species?)	---	---	---	---	+	---	5	28	8
chipping sparrow	---	+	---	---	---	+	---	26	1
rusty blackbird	---	---	---	---	---	---	---	---	26
common crow	---	1	---	---	---	---	10	10	---
chickadee (species?)	---	1	---	2	---	---	14	---	1
downy woodpecker	---	2	---	---	1	+	5	---	1
mourning dove	---	+	---	---	1	---	---	5	2
cardinal	---	---	---	1	---	+	7	---	---
house sparrow	---	3	---	---	---	3	2	---	---
robin	---	---	---	---	---	---	---	---	8
bobwhite	---	---	---	7	---	---	---	---	---
eastern bluebird	---	---	---	---	1	---	3	2	---
Carolina wren	---	---	---	---	---	---	5	1	---
American goldfinch	4	+	---	---	+	---	---	---	1
yellow-shafted flicker	---	---	---	---	+	---	2	1	2
red-bellied woodpecker	---	---	---	---	---	+	3	1	1
song sparrow	---	---	---	---	---	5	---	---	---
sharp-shinned hawk	---	---	---	1	---	+	2	---	1
ring-necked pheasant	---	1	---	---	+	3	---	---	---
tufted titmouse	---	---	---	---	---	---	2	---	---
short-eared owl	---	---	---	---	+	1	---	---	---
marsh hawk	---	---	---	---	---	---	---	1	---
red-tailed hawk	---	---	---	---	+	---	---	---	---
savannah sparrow	---	+	---	---	---	---	---	---	---
unidentified bird	---	---	---	---	---	---	---	2	---
total birds per 100 acres	9	50	9	24	207	76	152	188	163
number of species	2	12	1	6	12	11	15	13	14

horned lark in mechanically picked cornfields.

Soybean Stubble (Winter)

The tremendous increase in acreage of soybeans after 1920 has already been discussed. All but 21 of the 497 acres of bean stubble censused in winter were covered in the second census period, table 43; some or all of these 21 acres may have been stubble of field beans. Most of the soy-

bean acres censused were in central Illinois.

As a winter bird habitat, soybean stubble fields were more like cornfields than plowed ground and supported a similar avifauna. The average bird populations in the various zones and census years varied from almost zero to 3.9 birds per acre (4 to 387 birds per 100 acres, table 46); the populations were highest in the southern zone of the state.

Table 46.—Winter avifauna in Illinois soybean stubble fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused.

SPECIES	NORTHERN ZONE	CENTRAL ZONE		SOUTHERN ZONE	
	1956-57 (28)	1956-57 (187)	1957-58 (135)	1956-57 (58)	1957-58 (68)
Horned lark	4	52	43	60	77
Redwinged blackbird	—	—	—	—	293
Meadowlark (species?)	—	—	—	98	—
Lapland longspur	—	70	3	—	12
Mourning dove	—	—	—	50	—
Canada goose	—	—	—	17	—
American goldfinch	—	—	—	3	1
House sparrow	—	—	—	—	3
Slate-colored junco	—	—	—	3	—
Red-tailed hawk	—	—	—	2	—
Common crow	—	2	—	—	—
Red-bellied woodpecker	—	—	1	—	—
Savannah sparrow	—	—	—	—	1
Total birds per 100 acres	4	124	47	233	387
Number of species	1	3	3	7	6

Table 47.—Winter avifauna in Illinois plowed fields (birds per 100 acres) as determined by strip censuses in the three census zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE		CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (269)	1956-57 (68)	1906-07 (125)	1956-57 (46)	1957-58 (40)	1906-07 (18)	1956-57 (43)	1957-58 (50)
Horned lark	38	6	8	183	30	—	84	2
Slate-colored junco	—	—	22	—	—	—	—	—
Lapland longspur	1	6	—	9	—	—	—	—
House sparrow	6	—	—	—	5	—	—	—
Starling	—	1	—	—	—	—	2	—
Chickadee (species?)	—	—	2	—	—	—	—	—
Tree sparrow	1	—	—	—	—	—	—	—
Yellow-shafted flicker	+	—	—	—	—	—	—	—
Hawk (species?)	—	—	—	—	—	16	—	—
Total birds per 100 acres	46	13	32	192	35	16	86	2
Number of species	5	3	3	2	2	1	2	1

Of 13 species recorded in soybean fields, only the horned lark was found in all census winters and regions.

Plowed Fields (Winter)

In the two census periods, 659 acres of plowed fields were censused in winter, table 43. For the various census years and zones, the bird populations varied from almost zero to 1.9 birds per acre (2 to 192 birds per 100 acres, table 47); the average was about 0.5 bird per acre. Populations averaged highest in central Illinois. In the southern zone, there was a striking difference between the bird populations of this habitat and those of cornfields. Birds occurred in much greater numbers and variety in corn stubble than in bare plowed fields, tables 45 and 47.

At least nine species of birds were recorded within the plowed field transects in winter. The dominant species was the horned lark. The absence of cover appears to favor the horned lark; this one species comprised about 83 per cent of the statewide winter bird population seen on plowed ground. The Lapland longspur was recorded frequently in this habitat.

Small Grain Stubble Fields (Winter)

In terms of acreage, small grain stubble fields (wheat, oats, barley, rye) constituted the third largest winter habitat censused, table 43. About one-half of the 1,249 acres censused were covered in 1906-07.

In the fields censused in winter, the stems of harvested wheat, oats, or other

Table 48.—Winter avifauna in Illinois small grain stubble fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (223)	1956-57 (171)	1957-58 (21)	1906-07 (235)	1956-57 (137)	1957-58 (131)	1906-07 (205)	1956-57 (54)	1957-58 (70)
Arctic skua	---	21	---	---	---	38	---	251	9
Lapland longspur	72	19	---	---	54	---	---	---	---
Horned lark	12	3	34	20	20	16	12	---	3
Red-winged blackbird	+	2	---	---	9	3	25	80	---
Common crow	24	1	---	9	1	18	1	---	---
White-throated sparrow	2	---	---	4	---	---	22	---	---
Tree sparrow	+	---	14	1	---	1	6	2	---
Ring-necked pheasant	---	---	---	---	---	---	4	9	7
Chipping sparrow	---	---	---	+	---	---	1	6	11
Down-headed cowbird	---	---	---	---	---	---	---	19	---
House sparrow	2	---	---	5	3	---	---	---	---
Turnstone	---	---	5	---	---	---	1	2	---
Conte's sparrow	---	---	---	---	---	---	---	7	---
Ring-necked pheasant	---	1	---	---	---	5	---	---	---
Eastern bluebird	---	---	---	---	---	---	4	---	---
Yankee sparrow	---	---	---	---	---	---	---	4	---
Sharp-shinned hawk	---	---	---	---	---	---	1	---	1
Yellow-shafted flicker	---	1	---	---	---	---	1	---	---
Short-eared owl	---	---	---	+	---	+	---	---	---
Turkey vulture	---	---	---	---	---	---	1	---	---
Red-tailed hawk	---	---	---	---	---	---	1	---	---
Red-bellied woodpecker	---	---	---	---	---	---	1	---	---
Downy woodpecker	---	---	---	---	---	---	1	---	---
Loggerhead shrike	---	---	---	---	---	---	1	---	---
Red-colored junco	---	---	---	---	---	---	1	---	---
Blue bunting	+	---	---	---	---	---	---	---	---
Mocker (species?)	---	---	---	+	---	---	---	---	---
Unidentified bird	---	+	---	+	---	---	1	2	---
Total birds per 100 acres	113	48	53	40	87	81	85	382	31
Number of species	8	7	3	8	5	7	17	9	5

small grain, along with grass and weed growth of varying amounts, usually formed a fairly dense ground cover 6-12 inches in height, though often with some bare ground between rows.

Winter bird populations in this habitat were at least as variable in density as those in row crops and plowed fields. Populations in small grain stubble (all years and zones) ranged from 0.3 to 3.8 birds per acre (31 to 382 per 100 acres, table 48). In the second study period, populations averaged about 0.5 bird per acre in the northern zone, 0.8 in the central, and 1.8 in the southern. No consistent differences were apparent between population densities of 1906-07 and those of 1956-1958.

In the two study periods, at least 26 species of birds were identified within census strips in this winter habitat; the most varied avifauna was found in the

southern zone, table 48. Species recorded in this habitat in the largest number of census winters and zones were the horned lark, crow, meadowlarks, and tree sparrow. Species recorded less frequently but in relatively large numbers in some years were the Lapland longspur and starling. Small grain stubble is not a particularly important habitat for any species of bird, but it probably serves regularly as a marginal foraging habitat for most of the species listed in table 48. Meadowlarks, which in Illinois wintered regularly in the row crops and plowed fields only in the southern zone, were found in small grain stubble fields even in the northern zone.

Wheat Fields (Winter)

Winter wheat is grown principally in the southern and central zones and in rela-

Table 49.—Winter avifauna in Illinois wheat fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres. No wheat fields in the northern zone were censused in the winter of 1957-58.

SPECIES	NORTHERN ZONE		CENTRAL ZONE			SOUTHERN ZONE		
	1906-07	1956-57	1906-07	1956-57	1957-58	1906-07	1956-57	1957-58
	(57)	(21)	(203)	(125)	(112)	(335)	(163)	(130)
Horned lark.....	66	---	1	21	37	4	24	2
Tree sparrow.....	---	---	2	24	---	---	---	---
Lapland longspur.....	---	5	---	2	---	---	---	15
Meadowlark (species?).....	---	---	---	---	---	3	15	1
Starling.....	---	---	---	---	---	---	12	1
Common crow.....	7	---	1	1	1	---	---	---
Slate-colored junco.....	---	---	5	---	---	5	---	---
House sparrow.....	---	---	---	---	3	1	4	---
American goldfinch.....	---	5	---	---	---	---	1	---
Canada goose.....	---	---	---	---	---	---	4	---
Eastern bluebird.....	---	---	---	---	---	3	---	---
Sparrow hawk.....	---	---	+	1	---	1	---	---
Mourning dove.....	---	---	---	---	---	+	2	---
Brown-headed cowbird.....	---	---	---	---	---	---	2	---
Song sparrow.....	---	---	+	---	---	+	---	---
Marsh hawk.....	---	---	---	---	---	---	---	1
Killdeer.....	---	---	---	---	---	---	---	1
Mockingbird.....	---	---	---	---	---	1	---	---
Robin.....	---	---	---	---	---	---	1	---
Cardinal.....	---	---	1	---	---	---	---	---
Turkey vulture.....	---	---	---	---	---	+	---	---
Rough-legged hawk.....	---	---	+	---	---	---	---	---
Tufted titmouse.....	---	---	---	---	---	+	---	---
Unidentified bird.....	---	---	---	---	---	+	---	---
Total birds per 100 acres.....	73	10	11	49	41	20	66	20
Number of species.....	2	2	8	5	3	11	10	5

tively small acreage in the northern zone. In the two study periods, 1,146 acres were censused in winter, table 43; the acreage was distributed about equally between the two census periods.

In winter, the cover in this habitat is a short (3-5 inches), dense stand of green plants. In the thickest stands, the mat is uniform and has no bare soil between rows, but in most fields some bare soil is apparent between rows.

Bird populations in winter wheat fields were generally low; the densities in different census winters and zones ranged

from 0.1 to 0.7 bird per acre (10 to 73 birds per 100 acres, table 49). The numbers of birds in the central and southern zones were roughly comparable.

At least 23 species of birds were counted in the census strips of this winter habitat, table 49. The horned lark was the most abundant and most frequently sighted species. The Lapland longspur and tree sparrow were less numerous in this habitat than in the harvested cornfields, table 45.

The distribution of the meadowlarks in this winter habitat was similar to that in soybean stubble; that is, the birds were

Table 50.—Winter avifauna in Illinois pastures (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (440)	1956-57 (83)	1957-58 (26)	1906-07 (343)	1956-57 (38)	1957-58 (118)	1906-07 (208)	1956-57 (27)	1957-58 (66)
horned lark	11	6	12	29	13	22	13	62	6
red-winged blackbird	---	1	---	---	---	---	---	109	---
blue-colored junco	---	---	---	6	---	6	14	---	76
chipping sparrow	---	---	---	---	---	---	---	84	1
American goldfinch	22	---	---	35	---	---	---	11	---
Eastern bluebird	+	---	---	---	---	---	7	---	61
heron	---	1	---	---	---	---	---	51	---
meadowlark (species?)	---	1	---	---	---	2	9	4	30
tree sparrow	7	---	15	1	---	5	1	4	1
common crow	6	6	---	3	---	---	2	15	---
house sparrow	14	---	---	1	8	---	---	7	---
purple finch	---	---	---	---	---	---	17	---	---
cardinal	---	---	4	2	5	2	2	---	---
yellow-shafted flicker	+	---	---	1	---	---	3	4	1
downy woodpecker	---	---	---	---	---	---	9	---	---
star waxwing	---	---	---	---	---	8	---	---	---
blue jay	1	---	---	+	5	---	2	---	---
red-bellied woodpecker	---	1	---	2	---	2	1	---	---
tickadee (species?)	+	---	---	1	---	---	---	---	---
song sparrow	---	---	---	---	---	1	---	---	3
parrow hawk	---	---	---	---	3	---	1	---	---
common grackle	---	---	---	---	---	---	---	4	---
Lapland longspur	---	1	---	---	---	1	---	---	1
turkey vulture	---	---	---	---	---	---	3	---	---
black vulture	---	---	---	---	---	---	---	---	1
red-tailed hawk	---	---	---	---	---	---	1	---	---
fox sparrow	---	---	---	---	---	1	---	---	---
downy woodpecker	+	---	---	+	---	---	---	---	---
red-shouldered hawk	---	---	---	+	---	---	+	---	---
white-breasted nuthatch	---	---	---	+	---	---	---	---	---
marsh hawk	---	---	---	+	---	---	---	---	---
gray woodpecker	+	---	---	---	---	---	---	---	---
hawk (species?)	---	---	---	---	---	---	+	---	---
unidentified bird	---	---	---	---	---	2	+	4	---
total birds per 100 acres	67	17	31	82	34	52	85	359	181
number of species	11	7	3	14	5	10	16	10	11

restricted to the southern zone in these habitats, although they had a more northern distribution in small grain stubble and some other habitats with taller cover.

Pastures (Winter)

In the two study periods, 1,350 acres of pastureland were censused in winter, most of them in 1906-07, table 43. Most of the pastures censused were stands of bluegrass with a few scattered, low woody plants. The grass cover was dense, even in winter, and 3-8 inches in height.

Bird populations of pastureland in different census winters and zones varied from 0.2 to 3.6 birds per acre (17 to 359 birds per 100 acres, table 50); densities were lowest in the northern zone, highest in the southern. Population densities in pastureland varied less from zone to zone in 1906-07 than in 1956-1958; populations in the southern zone were conspicuously higher in 1956-1958 than in 1906-07. These data reflect a general trend: an increase in winter bird populations of southern Illinois since 1906-07.

Table 51.—Winter avifauna in Illinois fallow fields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (59)	1956-57 (28)	1957-58 (17)	1906-07 (34)	1956-57 (45)	1957-58 (34)	1906-07 (114)	1956-57 (52)	1957-58 (51)
Slate-colored junco	26	---	---	78	---	---	14	193	39
Tree sparrow	91	21	18	95	70	12	2	8	18
Bobwhite	---	---	---	33	16	33	---	---	129
Starling	---	14	---	---	---	---	---	52	4
American goldfinch	---	---	---	---	5	---	---	8	43
Horned lark	---	7	24	---	5	9	3	2	---
Song sparrow	---	4	---	9	---	---	15	---	18
Meadowlark (species?)	---	---	---	---	---	---	3	31	6
Cardinal	---	---	---	12	---	---	6	6	10
Chickadee (species?)	21	---	6	---	---	---	---	4	2
Ring-necked pheasant	---	14	12	---	---	---	---	---	---
Swamp sparrow	---	---	---	---	---	---	1	2	18
Field sparrow	---	---	---	---	---	---	---	19	---
Eastern bluebird	---	---	---	---	---	---	3	12	---
Downy woodpecker	3	---	---	6	---	---	3	---	---
Le Conte's sparrow	---	---	---	---	---	---	---	4	8
White-throated sparrow	---	---	---	---	---	---	---	10	---
Red-tailed hawk	---	4	---	---	---	---	1	2	---
House sparrow	---	---	---	---	5	---	2	---	---
Red-bellied woodpecker	---	---	---	---	---	---	1	2	2
Common crow	---	---	---	---	---	---	2	2	---
Sparrow hawk	---	4	---	---	---	---	---	---	---
Mourning dove	---	---	---	---	---	---	---	---	4
Mockingbird	---	---	---	---	---	---	---	---	4
Short-eared owl	---	---	---	---	2	---	---	---	---
Yellow-shafted flicker	---	---	---	---	---	---	2	---	---
Carolina wren	---	---	---	---	---	---	---	2	---
Long-billed marsh wren	---	---	---	---	---	---	---	2	---
Robin	---	---	---	---	---	---	---	---	2
Loggerhead shrike	---	---	---	---	---	---	---	2	---
White-crowned sparrow	---	---	---	---	---	---	---	---	2
Fox sparrow	---	---	---	---	---	---	---	2	---
Hairy woodpecker	---	---	---	---	---	---	1	---	---
Blue jay	---	---	---	---	---	---	1	---	---
<i>Melospiza</i> (species?)	---	---	---	---	---	---	---	6	---
Unidentified bird	---	---	---	---	---	---	1	2	2
Total birds per 100 acres	141	68	60	233	103	54	61	373	311
Number of species	4	7	4	6	6	3	16	21	16

In the two census periods, at least 32 species of birds were recorded in census strips of winter pastures, table 50. The horned lark was the dominant species, occurring in all census years and zones. In our data, there is a suggestion of winter habitat change for this species. In 1906-07, population densities of the horned lark were consistently higher in grassland habitat than in row crops, while, in the second study period, the lark population was higher in row crops and plowed fields than in grassland. Other species prominent in winter pasture were the junco, goldfinch, meadowlarks, tree sparrow, crow, and cardinal.

Fallow Fields (Winter)

Fallow fields, cultivated fields that have been deserted, make good winter bird habitat, supporting a variety of species and large numbers of birds.

Only 434 acres of fallow fields were censused in winter, about half of the acreage in each census period and half of it in the southern zone, table 43.

Winter bird populations in fallow fields in the different census zones and years varied from 0.5 to 3.7 birds per acre (54 to 373 birds per 100 acres, table 51). Highest populations were in the southern zone and lowest in the northern. In the northern and central zones, populations were conspicuously higher in the early study period, but, in the southern zone, they were higher in the later period. The same trends were apparent in winter bird populations of pastureland. These population differences between 1906-07 and 1956-1958 may be attributed largely to fluctuations in numbers of the junco and the tree sparrow and to a general increase in the winter bird population of southern Illinois since 1909.

In the two study periods, at least 34 species of birds were counted in winter census strips through fallow fields, table 51. Only the tree sparrow occurred in all years and all zones. The horned lark occurred in this habitat frequently, but in limited numbers. Other common species were the junco, bobwhite, and song sparrow. In southern Illinois, the meadowlarks, cardinal, swamp sparrow, and red-bellied woodpecker were among the species found in every census year.

Hayfields (Winter)

Hayfields present a varied picture in winter, as the fields have been cut at various times in the previous summer or fall. Fields with short growth have an abundance of bare ground and are attractive to such species as the horned lark and Lapland longspur. Well-grown fields with taller (at least 8 inches), more dense cover probably favor other species, such as the meadowlarks and bobwhite. In the two study periods, 873 acres of this habitat were censused in winter—about half of the total in each period, table 43.

Quantitatively, winter bird populations in hayfields compared roughly with those in mechanically picked cornfields, tables 45 and 52. In the different zones and census years, populations varied from about 0.1 to 2.0 birds per acre (7 to 202 birds per 100 acres, table 52). As in most other habitats, populations in hayfields averaged highest in the southern zone, lowest in the northern. They averaged higher in late than in early censuses, at least partly because of greater numbers of horned larks.

At least 23 species were recorded in this winter habitat, table 52. The horned lark was the principal species; the meadowlarks and Lapland longspur occurred in large numbers in some zones and years.

Shrub Areas (Winter)

Shrubs comprise a rich habitat for birds in winter. The shrub areas (including edge shrubs) censused in the two study periods harbored dense populations and a variety of species. Only 239 acres of this habitat were censused, all but 51 acres in 1956-1958 and more than half of it in the southern zone, table 43.

Bird populations in shrub areas in the different zones and census winters varied from 2.0 to 16.2 birds per acre (203 to 1,616 birds per 100 acres, table 53). Highest densities were in the southern and northern zones and in recent years. Sample sizes, which were small, may have tended to exaggerate the population density data. However, the 1906-07 census in this habitat consistently indicated markedly lower populations than those of the more recent census. To some extent, the apparent population differences between 1906-07 and 1956-1958 reflect actual population increases in a few species (for

example, the cardinal) and also a general trend, observable in a number of species (for example, the mourning dove), for birds to winter farther north in larger numbers in the second than in the first survey period.

At least 42 species of birds were found in shrub census strips in winter, table 53. Among those recorded in several censuses and in large numbers were the tree sparrow, junco, house sparrow, cardinal, bobwhite, and starling.

Forests (Winter)

The Illinois woodlands censused in winter were very rich in species and also in numbers of birds, table 54. In the two study periods, 764 acres of forest or woodlands were censused in winter, about 400 of these in 1956-1958; the largest acreage was in the southern zone, table 43.

Total bird populations in different census winters and zones varied from 0.4 to 3.9 birds per acre (45 to 394 birds per

100 acres, table 54). The populations averaged higher in the southern than in other zones. In the northern zone, the 1906-07 population was much lower than the populations recorded for recent years.

In the two study periods, at least 48 species of birds occurred in the forest strips censused in winter, table 54. Among species found in several census years and zones were the junco, tree sparrow, chickadees, blue jay, cardinal, tufted titmouse, crow, goldfinch, red-bellied woodpecker, downy woodpecker, white-breasted nuthatch, song sparrow, and hairy woodpecker. The bobwhite, Carolina wren, robin, red-headed woodpecker, and yellow-shafted flicker were among the species found in every census year in the southern zone of Illinois.

Comparison of Data for Winter Habitats

Partly because of a breakdown in territorial behavior that occurs in winter,

Table 52.—Winter avifauna in Illinois hayfields (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07 (172)	1956-57 (145)	1957-58 (37)	1906-07 (164)	1956-57 (134)	1957-58 (46)	1906-07 (90)	1956-57 (54)	1957-58 (31)
Horned lark	—	21	38	4	34	71	2	6	26
Meadowlark (species?)	—	8	—	—	1	—	55	22	68
Lapland longspur	—	11	—	—	11	110	—	—	6
Bobwhite	—	—	—	—	—	—	20	—	29
Slate-colored junco	—	—	—	2	6	—	—	37	—
Eastern bluebird	—	—	—	—	—	—	—	9	20
Sprague's pipit	—	—	—	—	—	—	—	13	13
Starling	—	1	—	—	1	21	—	—	—
Mourning dove	—	—	—	—	1	—	—	—	23
Killdeer	—	—	—	—	—	—	5	18	—
American goldfinch	1	1	—	—	—	—	—	13	—
Tree sparrow	2	4	—	—	1	—	—	—	—
Common crow	3	1	—	1	—	—	—	—	—
Song sparrow	—	1	—	—	—	—	2	—	—
Yellow-shafted flicker	—	—	—	1	—	—	1	—	—
Blue jay	—	—	—	2	—	—	—	—	—
Chickadee (species?)	—	—	—	—	—	—	2	—	—
Turkey vulture	—	—	—	—	—	—	1	—	—
Rough-legged hawk	—	—	—	1	—	—	—	—	—
Sparrow hawk	—	—	—	1	—	—	—	—	—
Ring-necked pheasant	—	1	—	—	—	—	—	—	—
Downy woodpecker	—	1	—	—	—	—	—	—	—
House sparrow	1	—	—	—	—	—	—	—	—
Hawk (species?)	—	—	—	1	—	—	1	—	—
Total birds per 100 acres	7	50	38	13	55	202	89	118	185
Number of species	4	10	1	7	7	3	8	7	7

bird populations at this time of year tend to have a definitely "clumped" distribution. At this season, large areas of a particular habitat may be void of birds, while the bird population of the habitat may be

flocked in relatively small areas. At this season, also, birds tend to range farther and to be less restricted to a particular habitat than in summer. The avifaunal characteristics of a given habitat are thus

Table 53.—Winter avifauna in Illinois shrub areas (birds per 100 acres) as determined by strip censuses in the three zones; the figures include edge shrubs. Figures in parentheses indicate numbers of acres censused.

SPECIES	NORTHERN ZONE		CENTRAL ZONE		SOUTHERN ZONE		
	1906-07 (18)	1956-57 (13)	1956-57 (39)	1957-58 (35)	1906-07 (33)	1956-57 (60)	1957-58 (41)
Tree sparrow.....	---	1,002	460	301	9	191	113
Slate-colored junco.....	---	32	84	136	73	245	681
House sparrow.....	---	388	143	69	42	91	7
Bobwhite.....	62	158	---	14	112	73	---
Cardinal.....	---	---	18	52	3	98	83
Starling.....	---	---	25	116	---	100	12
Mourning dove.....	---	---	---	---	---	20	240
Redwinged blackbird.....	---	---	---	---	---	290	---
Robin.....	---	---	---	---	---	87	39
Chickadee (species?).....	45	---	15	9	9	12	25
Cedar waxwing.....	---	---	---	124	---	---	---
Blue jay.....	68	8	5	3	---	8	12
Song sparrow.....	---	---	5	---	6	45	47
White-crowned sparrow.....	---	---	---	---	---	101	2
American goldfinch.....	---	---	2	---	---	30	66
Downy woodpecker.....	11	---	15	6	3	13	5
Red-bellied woodpecker.....	---	---	2	9	3	18	15
Brown-headed cowbird.....	---	---	---	---	---	50	---
Eastern bluebird.....	---	---	---	---	9	21	5
White-throated sparrow.....	---	---	---	---	---	28	7
Mockingbird.....	---	---	---	---	---	3	29
Purple finch.....	---	---	---	---	27	---	---
Common crow.....	---	16	---	---	---	2	---
Fox sparrow.....	---	---	---	---	9	7	---
Carolina wren.....	---	---	---	3	---	7	5
Rufous-sided towhee.....	---	---	---	3	---	7	5
Swamp sparrow.....	---	---	---	---	---	7	7
Tufted titmouse.....	---	---	2	3	6	2	---
Hairy woodpecker.....	11	---	---	---	---	---	---
Field sparrow.....	---	---	---	---	---	5	5
White-breasted nuthatch.....	6	---	---	---	3	---	---
Long-eared owl.....	---	---	2	6	---	---	---
Yellow-shafted flicker.....	---	---	---	---	---	2	5
Loggerhead shrike.....	---	---	---	---	---	2	5
Meadowlark (species?).....	---	---	---	---	---	7	---
Ruby-crowned kinglet.....	---	---	---	---	---	2	2
Myrtle warbler.....	---	---	---	---	---	2	2
Harris' sparrow.....	---	---	---	3	---	---	---
Marsh hawk.....	---	---	---	---	---	---	2
Sparrow hawk.....	---	---	---	---	---	2	---
Saw-whet owl.....	---	---	2	---	---	---	---
Hermit thrush.....	---	---	---	---	---	2	---
<i>Melospiza</i> (species?).....	---	---	---	---	---	8	---
<i>Zonotrichia</i> (species?).....	---	---	---	---	---	---	5
Unidentified bird.....	---	8	---	3	---	28	20
Total birds per 100 acres.....	203	1,612	780	860	314	1,616	1,451
Number of species.....	6	6	14	16	14	34	26

Table 54.—Winter avifauna in Illinois forests (birds per 100 acres) as determined by strip censuses in the three zones. Figures in parentheses indicate numbers of acres censused; + indicates less than 1 bird per 100 acres.

SPECIES	NORTHERN ZONE			CENTRAL ZONE			SOUTHERN ZONE		
	1906-07	1956-57	1957-58	1906-07	1956-57	1957-58	1906-07	1956-57	1957-58
	(65)	(24)	(21)	(50)	(66)	(86)	(241)	(120)	(91)
Slate-colored junco	---	96	24	---	14	52	68	35	129
Tree sparrow	6	92	---	59	157	3	9	2	---
American goldfinch	---	21	97	44	1	3	+	7	---
Common crow	12	17	---	8	81	7	5	3	8
Chickadee (species?)	9	8	44	6	9	12	15	18	18
Cardinal	---	8	---	6	14	13	10	27	37
Blue jay	1	---	19	2	23	8	29	7	18
Tufted titmouse	---	4	5	2	11	16	24	20	11
Bobwhite	---	---	---	---	18	---	10	12	25
Red-bellied woodpecker	1	4	15	2	4	10	5	12	7
Downy woodpecker	9	4	10	2	1	7	3	7	11
White-breasted nuthatch	3	4	10	16	---	5	2	2	2
Song sparrow	---	---	15	---	6	1	2	1	12
Carolina wren	---	---	---	---	---	5	4	13	7
White-throated sparrow	---	---	---	---	---	---	7	---	20
House sparrow	---	21	---	---	1	2	---	2	---
Canada goose	---	---	---	---	---	---	---	---	26
Starling	---	---	---	---	1	---	---	24	---
Robin	---	---	---	---	1	---	1	12	10
Eastern bluebird	---	---	---	---	---	---	15	9	---
Turkey vulture	---	---	---	---	---	---	24	---	---
Red-headed woodpecker	---	---	---	---	3	1	1	2	15
Hairy woodpecker	3	---	---	2	6	3	3	2	---
Mourning dove	---	4	---	---	1	---	---	14	---
Yellow-shafted flicker	---	---	---	---	---	1	2	2	7
Red-tailed hawk	---	4	---	---	---	---	---	1	4
Mallard	---	---	---	---	---	---	---	---	9
Purple finch	---	---	---	---	---	3	5	---	---
Rufous-sided towhee	---	---	---	---	---	---	3	---	3
Yellow-bellied sapsucker	---	---	---	---	---	---	---	1	4
Swamp sparrow	1	---	---	---	---	---	---	1	1
Long-eared owl	---	---	---	2	---	---	+	---	---
Myrtle warbler	---	---	---	---	---	---	+	2	---
Red-shouldered hawk	---	---	---	---	---	---	1	1	---
Brown creeper	---	---	---	---	---	---	1	---	1
Field sparrow	---	---	---	---	---	---	1	1	---
Winter wren	---	---	---	---	---	---	---	2	---
Mockingbird	---	---	---	---	---	---	---	---	2
Sparrow hawk	---	---	---	---	---	---	1	---	---
Great horned owl	---	---	---	---	---	---	---	1	---
Belted kingfisher	---	---	---	---	---	---	---	---	1
Pileated woodpecker	---	---	---	---	---	---	1	---	---
Hermit thrush	---	---	---	---	---	---	---	---	1
Golden-crowned kinglet	---	---	---	---	---	1	---	---	---
Meadowlark (species?)	---	---	---	---	---	---	---	1	---
Redwinged blackbird	---	---	---	---	---	---	---	1	---
Fox sparrow	---	---	---	---	---	---	---	1	---
Golden eagle	---	---	---	---	---	---	+	---	---
Hawk (species?)	---	---	---	---	---	---	3	---	---
Dendrocopos (species?)	---	---	---	---	---	---	---	1	---
Unidentified bird	---	---	---	---	---	2	---	8	5
Total birds per 100 acres	45	287	239	151	352	155	257	255	394
Number of species	9	13	9	12	18	19	32	33	26

less clearly defined in winter than in summer.

Number of Birds.—Because winter bird populations in nonwoody habitats are generally very sparse in northern latitudes and high in southern latitudes, it is somewhat misleading to discuss average winter bird populations for Illinois as a whole, but for comparative purposes it is convenient to use a single figure to represent each habitat in the state. Mean density figures for winter bird populations in various habitats in the northern, central, and southern zones of Illinois are presented in figs. 25–27.

Average populations for the state, as shown by surveys in January, 1957 and 1958, were 54 birds per 100 acres in winter wheat, 63 in hayfields, 82 in pastures, 85 in plowed ground, 113 in small grain stubble, 135 in soybean stubble, 153 in mechanically picked corn, 206 in fallow fields, 289 in forest, and 1,325 in shrubbery. To a very great degree, the Illinois avifauna depends on woody habitats. Still, the open habitats are probably being increasingly occupied by birds. For example, cornfields had an average January population of 48 birds per 100 acres in 1907 (stubble fields) and 153 in 1957 (mechanically picked fields).

Number of Species.—The variety of Illinois bird life in winter habitats tended to parallel the population densities in these habitats, but, more directly, it probably reflected the complexity of the habitats. Plowed ground had the fewest species of birds (9), and soybean stubble, with only slightly more cover, had 13 species in the acreage censused, followed by winter wheat and hayfields (each 23) and small grain stubble (26). Hand-picked cornfields had 26 species and corn stubble or mechanically picked fields had 29 (this large number of species reflects, in part, the large acreage covered). Notably more varied were the avifaunas in pastures (32 species recorded), fallow fields (34), shrub areas, including edge (42), and forest (48), tables 44–54.

Statewide Winter Populations

In summer, row crops and plowed ground (habitats that are characterized by large areas of bare ground) occupy more Illinois land than any other types of

habitat. In winter, because of fall plowing, these habitats are even more extensive than in summer.

In the winter of 1906–07, there were 12,398,000 acres of row-crop stalks and stubble (corn, 10,500,000; garden vegetables, 287,000 acres) and 1,611,000 acres of plowed ground, with a population of about 9,018,000 birds. About 504,000 (5 per cent) of these were horned larks, most of which were concentrated on plowed ground. By the winter of 1956–57, there were 15,053,000 acres of row-crop stubble (corn, 8,939,000 acres; garden vegetables, 75,000 acres; soybeans, 4,785,000 acres) and 1,253,000 acres of plowed ground, with a state bird population estimated at about 21,448,000, of which about 7,502,000 (35 per cent) were horned larks.

In all census winters, birds in these row-crop or plowed-ground habitats tended to be concentrated in the central and southern zones. This concentration was particularly noticeable in the winter of 1906–07, when only about 217,000 birds were in cornfields of the northern zone, while 6,145,000 birds (76 per cent of the statewide cornfield population) were in cornfields of the southern zone. By contrast, in 1956–57, about 1,339,000 birds (1957–58, 1,877,000) were in cornfields of the northern zone and 5,118,000 (43 per cent of the statewide cornfield population) were in cornfields of the southern zone. The data suggest that birds of the Middle West were wintering farther north in 1956–1958 than in 1906–07, but to a large extent the data reflect a marked increase in the number of horned larks. Both the horned lark and Lapland longspur favor the row-crop or plowed-ground habitats, and both are hardy species that survive well in northern latitudes. Paradoxically, while plowed ground and row crops were the poorest of the summer habitats (in terms of population density), they comprised some of the best of the nonwoody habitats in winter. Bird populations in these habitats increased, partly from an expansion of the habitat and partly from an increase in population density of certain species. This situation is a prime example of man inadvertently cultivating a habitat for a particular species (in this case, the horned lark).

In the winter of 1906-07, there were estimated to be 2,789,000 acres of small grain stubble in the state, with a bird population numbering about 2,078,000. In the winter of 1956-57, there were about 2,440,000 acres of small grain stubble, with a bird population estimated at 2,129,000. While small grain stubble is a good habitat for winter, most of this habitat is in the northern half of the state, and the bird species (meadowlarks and various native sparrows) that make use of such cover have a more southern distribution, while the northern-ranging species (horned lark and Lapland longspur) tend to avoid tall, dense cover.

In winter wheat, a consistently poor winter habitat, the 1906-07 avian population was estimated to be only about 455,000 birds on the 2,325,000 acres of this habitat in Illinois. In 1956-57, there were about 1,004,000 birds on the 1,639,000 acres of winter wheat in the state and, in 1957-58, only 486,000 birds on 1,787,000 acres.

Pasture, which is a rich summer habitat, had surprisingly low bird populations in winter. In the winter of 1906-07, on about 6,085,000 acres of pastureland, there were about 4,936,000 birds. Reduction in pasture acreage (to 2,004,000 acres) brought the winter bird population in this habitat down to about 2,000,000 (1,761,000 in 1956-57 and 2,199,000 in 1957-58).

The acreage of fallow fields in winter was reduced from about 1,496,000 acres in 1906-07 to about 1,034,000 acres in 1956-57, but, because of an increase in population density, the statewide winter bird population in this habitat was estimated to be higher in 1956-57 (2,618,000) and 1957-58 (2,114,000) than in 1906-07 (1,266,000).

Hayfields in the winter of 1906-07 had a population estimated at only 1,460,000 birds on 3,245,000 acres. With increased acreage (to 5,254,000 acres), the population was estimated to be 3,601,000 birds in the winter of 1956-57.

The woody habitats (shrub and forest) had very high bird populations in winter as in summer. In the winter of 1906-07, 469,000 acres of shrub-grown land had an estimated population of 1,422,000 birds. Though there was little change in acre-

age by 1956-57 (507,000 acres), the population in this habitat was about 7,210,000 birds; the 1957-58 population was nearly as high (6,433,000 birds). Several species of birds were represented in this apparent increase between the winters of 1906-07 and 1956-57. The change may be further evidence that birds in the Middle West tended to winter farther north in 1956-1958 than in 1906-07.

Forest acreage increased from about 3,459,000 acres in 1906-07 to 3,996,000 acres in 1956-1958. The winter bird population in forest increased far out of proportion to the acreage change, from about 6,654,000 birds in 1906-07 to about 11,079,000 in 1956-57, and the 1957-58 population was even higher (approximately 12,985,000 birds).

In all of these types of winter habitats censused in Illinois, there was a population estimated at 27,289,000 birds on 32,267,000 acres in 1906-07 and 50,851,000 birds on 31,927,000 acres in 1956-57. Even the lower population in 1957-58 (approximately 47,492,000 birds on 31,483,000 acres) was well above the 1906-07 level.

The difference in winter bird populations between 1906-07 and 1956-1958 cannot be explained solely as annual variation. There are probably at least two major causes of the increase: (1) actual population increases in a few species, such as the horned lark, and (2) changes in winter distribution of several species, with many birds of the Middle West wintering farther north in 1956-1958 than in 1906-07.

Much of the Illinois winter bird population was in the southern zone of the state. This zone, as we have defined it, includes about 15,947,000 acres of land (44.5 per cent of the state), which contained about 18,000,000 birds (65 per cent of the state population) in 1906-07, about 30,000,000 birds (60 per cent) in 1956-57, and about 32,000,000 birds (67 per cent) in 1957-58. The northern zone (8,778,000 acres of land or 24.5 per cent of the state acreage) had winter populations estimated to total 3,500,000 birds (13 per cent of the state population) in 1906-07, 5,384,000 birds (11 per cent) in 1956-57, and 5,157,000 birds (11 per cent) in 1957-58.

The quantitative distribution of birds in the state in winter can best be observed in the mean density figures for each zone. Mean population densities (calculated number of birds in an area divided by the number of acres in the area) for all non-urban habitats in the three zones of the state in January, 1907, were 0.5 in the northern zone (0.7 in 1957), 0.7 in the central (1.6 in 1957), and 1.3 in the southern (2.1 in 1957). (Bird populations in urban areas and urban acreage were not included in the calculation of the mean densities because we lacked winter data for this habitat.) The density of the winter population of birds in nonurban Illinois habitats increased between 1907 and 1957; the increase in the northern zone (about 41 per cent increase above the 1907 level) lagged behind that in the southern zone (about 64 per cent increase above the 1907 level).

It should be noted here that there is a limit to the number of birds that can survive on a given land area in a particular climate. The January, 1907, population was presumably closer to saturation level in the northern zone of Illinois than in the southern zone. This saturation level may vary somewhat from year to year, but it is set within definite limits by climate, soil, land use, and other factors. How much more the winter population of Illinois birds may increase with the existing climate and agricultural situation cannot be predicted; additional points of reference on this problem would be extremely interesting. Some additional impression of the influence of winter climate on bird distribution may be obtained by comparing summer densities with winter densities in the three zones, fig. 28.

In view of the mass migration of species from the state following the nesting season, the winter population of birds, when compared with the summer population, was surprisingly high. We estimated that in the winter of 1906-07 the population was about 30,936,000 birds on approximately 34,917,000 acres (total land area of Illinois less urban and road-surface areas). This acreage included some types of habitats not censused (such as home gardens, airports, and cemeteries) and is therefore greater than the acreage for the census figures on page 457. The estimated

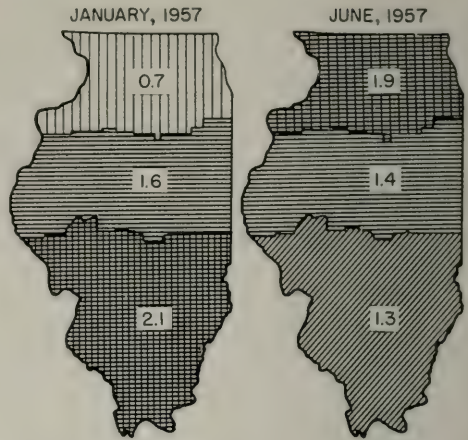


Fig. 28.—Distribution of bird populations in Illinois in winter and summer. Hatching represents density of the bird population in each of the three zones of the state. The numerals in each zone represent the mean number of birds per acre for all nonurban habitats censused in the zone in January or June, 1957.

population on the same acreage in the summer of 1909 was 56,949,000 birds. We estimated that in the winter of 1956-57 the population was about 54,111,000 birds on approximately 33,672,000 acres (total land area of Illinois less urban and road-surface acreage). The estimated population on the same acreage in the following summer (1957) was 49,464,000. Thus, the winter population in some years may exceed the summer level. The size of the winter populations was particularly impressive in view of the fact that most Illinois birds in winter were in the southern half of the state, fig. 28.

ACCOUNT OF SPECIES

In four summer seasons (1907, 1909, 1957, and 1958) and three winters (1906-07, 1956-57, and 1957-58) in Illinois, 168 species of birds were identified in census strips. Nine additional species were identified outside the census strips. The census method was not intended to provide complete qualitative data on the avifauna of Illinois, but the list of species recorded, table 55, includes most of the species that winter or breed in terrestrial habitats of the state.

Smith & Parmalee (1955) included 384 species in their check list of Illinois birds. Ninety-one of these are extinct or of only

Table 55.—Species of birds encountered in strip censuses in the three zones of Illinois; x indicates a species recorded within one or more of the census strips; * indicates a species recorded in the zone indicated but outside one of the census strips.

SPECIES	WINTER						SUMMER					
	1906-07			1956-57 and 1957-58			1907 and 1909			1957 and 1958		
	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern
Horned grebe, <i>Podiceps auritus</i>	—	—	—	—	—	—	—	—	—	x		
Great blue heron, <i>Ardea herodias</i>	—	—	—	—	—	—		*	x	x		x
Green heron, <i>Butorides virescens</i>	—	—	—	—	—	—	*	x	x	x	x	x
Little blue heron, <i>Florida caerulea</i>	—	—	—	—	—	—	—	—	—			*
Common egret, <i>Casmerodius albus</i>	—	—	—	—	—	—	—	—	—			x
Black-crowned night heron, <i>Nycticorax nycticorax</i>	—	—	—	—	—	—	x			x	x	*
Least bittern, <i>Ixobrychus exilis</i>	—	—	—	—	—	—	—	—	—	x		x
American bittern, <i>Botaurus lentiginosus</i>	—	—	—	—	—	—	—	—	—	x		
Canada goose, <i>Branta canadensis</i>	—	—	—	—	—	x	—	—	—			*
Blue goose, <i>Chen caerulescens</i>	—	—	—	—	—	x	—	—	—	—	—	—
Mallard, <i>Anas platyrhynchos</i>	—	—	—	—	—	x	—	—	—	x		*
Black duck, <i>Anas rubripes</i>	—	—	—	—	—	—	—	—	—	*		
Blue-winged teal, <i>Anas discors</i>	—	—	—	—	—	—	—	—	—	x	x	
Wood duck, <i>Aix sponsa</i>	—	—	—	—	—	—	—	—	—		*	
Lesser scaup, <i>Aythya affinis</i>	—	—	—	—	—	—	*			—	—	—
Turkey vulture, <i>Cathartes aura</i>	—	—	x	—	—	*	*	x		x	x	
Black vulture, <i>Coragyps atratus</i>	—	—	—	—	x	—	—	—	—	—	—	—
Cooper's hawk, <i>Accipiter cooperii</i>	—	—	—	—	—	—	—	—	—	x		
Red-tailed hawk, <i>Buteo jamaicensis</i>	—	—	x	x	x	x	x	x	x	x	x	x
Red-shouldered hawk, <i>Buteo lineatus</i>	—	—	x	—	—	—	—	x		*	x	
Broad-winged hawk, <i>Buteo platypterus</i>	—	—	x	—	—	—	—	—	—	*		
Rough-legged hawk, <i>Buteo lagopus</i>	x	x	—	*	*	—	—	—	—	—	—	—
Golden eagle, <i>Aquila chrysaetos</i>	—	—	x	—	—	—	—	—	—	—	—	—
Bald eagle, <i>Haliaeetus leucocephalus</i>	—	—	*	—	—	—	—	—	—	—	—	—
Marsh hawk, <i>Circus cyaneus</i>	—	x	—	*	*	x	x			x	*	
Sparrow hawk, <i>Falco sparverius</i>	—	x	x	x	x	x	x	x	x	x	x	*
Greater prairie chicken, <i>Tympanuchus cupido</i>	—	—	—	—	—	—	x	x		—	—	—
Bobwhite, <i>Colinus virginianus</i>	x	x	x	x	x	x	x	x	x	x	x	x
Ring-necked pheasant, <i>Phasianus colchicus</i>	—	—	—	x	x	*	—	—	—	x	x	
Gray partridge, <i>Perdix perdix</i>	—	—	—	x	—	—	—	—	—	x		
King rail, <i>Rallus elegans</i>	—	—	—	—	—	—	*			x		
Virginia rail, <i>Rallus limicola</i>	—	—	—	—	—	—	—	—	—	x		
Sora, <i>Porzana carolina</i>	—	—	—	—	—	—	x			—	—	—
Common gallinule, <i>Gallinula chloropus</i>	—	—	—	—	—	—	—	—	—	*		
American coot, <i>Fulica americana</i>	—	—	—	—	—	—	—	—	—	x		*
Killdeer, <i>Charadrius vociferus</i>	—	—	x	—	—	x	x	x	x	x	x	x
American woodcock, <i>Philohela minor</i>	—	—	—	—	—	—	—	x		—	—	—
Common snipe, <i>Capella gallinago</i>	—	—	—	—	—	—	—	—	—	x		
Upland plover, <i>Bartramia longicauda</i>	—	—	—	—	—	—	x	x	x	x	x	x
Spotted sandpiper, <i>Actitis macularia</i>	—	—	—	—	—	—	—	x	x	x		*
Herring gull, <i>Larus argentatus</i>	—	—	*	—	—	x	—	—	—	—	—	—
Ring-billed gull, <i>Larus delawarensis</i>	—	—	—	—	—	x	—	—	—	—	—	—
Black tern, <i>Chlidonias niger</i>	—	—	—	—	—	—	—	—	—	x		
Rock dove, <i>Columba livia</i>	—	—	—	—	—	—	—	—	—	x	x	x
Mourning dove, <i>Zenaidura macroura</i>	x	x	x	x	x	x	x	x	x	x	x	x
Yellow-billed cuckoo, <i>Coccyzus americanus</i>	—	—	—	—	—	—	x	x	x	x	x	x
Black-billed cuckoo, <i>Coccyzus erythrophthalmus</i>	—	—	—	—	—	—	—	x	x	x	*	x
Great horned owl, <i>Bubo virginianus</i>	—	—	—	—	x	—	—	—	—	*	x	
Barred owl, <i>Strix varia</i>	—	—	—	—	—	—	—	—	x			x
Long-eared owl, <i>Asio otus</i>	—	x	x	—	x	—	—	—	—	—	—	—

Table 55.—Continued

SPECIES	WINTER						SUMMER					
	1906-07			1956-57 and 1957-58			1907 and 1909			1957 and 1958		
	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern
Short-eared owl, <i>Asio flammeus</i>				x	x							
Saw-whet owl, <i>Aegolius acadicus</i>				x								
Whip-poor-will, <i>Caprimulgus vociferus</i>												x
Common nighthawk, <i>Chordeiles minor</i>							x	x		*	*	x
Chimney swift, <i>Chaetura pelagica</i>							x	x	x	x	x	x
Ruby-throated hummingbird, <i>Archilochus colubris</i>							x	x		x	x	x
Belted kingfisher, <i>Megasceryle alcyon</i>			*		x		x	x		x	x	*
Yellow-shafted flicker, <i>Colaptes auratus</i>	x	x	x	x	x	x	x	x	x	x	x	x
Pileated woodpecker, <i>Dryocopus pileatus</i>						*						x
Red-bellied woodpecker, <i>Centurus carolinus</i>	x	x	x	x	x	x		x		*	x	x
Red-headed woodpecker, <i>Melanerpes erythrocephalus</i>			x		x	x	x	x	x	x	x	x
Yellow-bellied sapsucker, <i>Sphyrapicus varius</i>					x							
Hairy woodpecker, <i>Dendrocopos villosus</i>	x	x	x		x	x		x	x	*	x	x
Downy woodpecker, <i>Dendrocopos pubescens</i>	x	x	x	x	x	x	*	*	x	x	x	x
Eastern kingbird, <i>Tyrannus tyrannus</i>							x	x	x	x	x	x
Great crested flycatcher, <i>Myiarchus crinitus</i>							*	x	x	x	x	x
Eastern phoebe, <i>Sayornis phoebe</i>							x	x	x	x	*	x
Yellow-bellied flycatcher, <i>Empidonax flaviventris</i>								x				
Acadian flycatcher, <i>Empidonax virescens</i>									x	x	x	x
Traill's flycatcher, <i>Empidonax traillii</i>								x	x	x	x	x
Least flycatcher, <i>Empidonax minimus</i>								x				
Eastern wood pewee, <i>Contopus virens</i>							x	*	x	x	x	x
Horned lark, <i>Eremophila alpestris</i>	x	x	x	x	x	x	x	x	x	x	x	x
Tree swallow, <i>Iridoprocne bicolor</i>										x	x	
Bank swallow, <i>Riparia riparia</i>							x	x	x	x	x	
Rough-winged swallow, <i>Stelgidopteryx ruficollis</i>										x	x	x
Barn swallow, <i>Hirundo rustica</i>							x	x	x	x	x	x
Cliff swallow, <i>Petrochelidon pyrrhonota</i>								x	x	x		*
Purple martin, <i>Progne subis</i>								x	x	x	x	x
Blue jay, <i>Cyanocitta cristata</i>	x	x	x	x	x	x	x	x	x	x	x	x
Common crow, <i>Corvus brachyrhynchos</i>	x	x	x	x	x	x	x	x	x	x	x	x
Chickadee, <i>Parus</i> spp.	x	x	x	x	x	x	*	*	x	x	x	x
Black-capped chickadee, <i>Parus atricapillus</i>	x	x	x		*					x		
Carolina chickadee, <i>Parus carolinensis</i>		x	x			x		*			x	x
Tufted titmouse, <i>Parus bicolor</i>	*	x	x	x	x	x			x	x	x	x
White-breasted nuthatch, <i>Sitta carolinensis</i>	x	x	x	x	x	x		x		x	x	x
Brown creeper, <i>Certhia familiaris</i>	x	*	x		x							
House wren, <i>Troglodytes aedon</i>							*	x	x	x	x	x
Winter wren, <i>Troglodytes troglodytes</i>	*		*			x						
Bewick's wren, <i>Thryomanes bewickii</i>								*	x			x
Carolina wren, <i>Thryothorus ludovicianus</i>	*		x		x	x			x		x	x
Long-billed marsh wren, <i>Telmatoodytes palustris</i>				x	x					x		
Short-billed marsh wren, <i>Cistothorus platensis</i>										x	*	x
Mockingbird, <i>Mimus polyglottos</i>			x			x		x	x		x	x
Catbird, <i>Dumetella carolinensis</i>							x	x	x	x	x	x
Brown thrasher, <i>Toxostoma rufum</i>							x	x	x	x	x	x
Robin, <i>Turdus migratorius</i>	*		x		x	x	x	x	x	x	x	x
Wood thrush, <i>Hylocichla mustelina</i>								*	x	x	x	x
Hermit thrush, <i>Hylocichla guttata</i>						x						
Swainson's thrush, <i>Hylocichla ustulata</i>							x					

Table 55.—Continued

SPECIES	WINTER						SUMMER					
	1906-07			1956-57 and 1957-58			1907 and 1909			1957 and 1958		
	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern
Eastern bluebird, <i>Sialia sialis</i>	x		x	x	x		x	x	x	x	x	x
Blue-gray gnatcatcher, <i>Poliophtila caerulea</i>	--	--	*	--	--	--	--	--	--	x	x	x
Golden-crowned kinglet, <i>Regulus satrapa</i>				x			--	--	--	--	--	--
Ruby-crowned kinglet, <i>Regulus calendula</i>	--	--			x		--	--	--	--	--	--
Water pipit, <i>Anthus spinoletta</i>	--	--			x					--	--	--
Sprague's pipit, <i>Anthus spragueii</i>	--	--			x		--	--	--	--	--	--
Cedar waxwing, <i>Bombycilla cedrorum</i>	--	--		x	x		--	--	--	*		
Northern shrike, <i>Lanius excubitor</i>	--	--		*						--	--	--
Loggerhead shrike, <i>Lanius ludovicianus</i>		x	x	*	x	x	x	x	x	x	x	x
Starling, <i>Sturnus vulgaris</i>	--	--		x	x	x	--	--	--	x	x	x
White-eyed vireo, <i>Vireo griseus</i>	--	--		--	--				x			x
Bell's vireo, <i>Vireo bellii</i>	--	--		--	--		--	--		x	x	
Yellow-throated vireo, <i>Vireo flavifrons</i>	--	--		--	--		--	--		x	x	x
Red-eyed vireo, <i>Vireo olivaceus</i>	--	--		--	--		x	x	x	x	x	x
Warbling vireo, <i>Vireo gilvus</i>	--	--		--	--		x		x	x	x	x
Black-and-white warbler, <i>Mniotilta varia</i>	--	--		--	--				*			x
Prothonotary warbler, <i>Protonotaria citrea</i>	--	--		--	--				x			x
Worm-eating warbler, <i>Helminthophila vermivorus</i>	--	--		--	--		--	--				x
Swainson's warbler, <i>Limnithlypis swainsonii</i>	--	--		--	--				x	--	--	--
Parula warbler, <i>Parula americana</i>	--	--		--	--		x					x
Yellow warbler, <i>Dendroica petechia</i>	--	--		--	--		x		x		x	x
Magnolia warbler, <i>Dendroica magnolia</i>	--	--		--	--			x		--	--	--
Myrtle warbler, <i>Dendroica coronata</i>	--	x			x	--	--	--		--	--	--
Cerulean warbler, <i>Dendroica cerulea</i>	--	--		--	--		--	--		x	x	x
Yellow-throated warbler, <i>Dendroica dominica</i>	--	--		--	--		--	--				*
Chestnut-sided warbler, <i>Dendroica pensylvanica</i>	--	--		--	--		x			--	--	--
Pine warbler, <i>Dendroica pinus</i>	--	--		--	--		--	--				*
Prairie warbler, <i>Dendroica discolor</i>	--	--		--	--		--	--				x
Palm warbler, <i>Dendroica palmarum</i>	--	--		--	--		x			--	--	--
Ovenbird, <i>Seiurus aurocapillus</i>	--	--		--	--		--	--		x	x	
Louisiana waterthrush, <i>Seiurus motacilla</i>	--	--		--	--				x	x		x
Kentucky warbler, <i>Oporornis formosus</i>	--	--		--	--		--	--			x	x
Yellowthroat, <i>Geothlypis trichas</i>	--	--		--	--		x	x	x	x	x	x
Yellow-breasted chat, <i>Icteria virens</i>	--	--		--	--		*		x		x	x
Hooded warbler, <i>Wilsonia citrina</i>	--	--		--	--		--	--				x
American redstart, <i>Setophaga ruticilla</i>	--	--		--	--		x	x		x	x	x
House sparrow, <i>Passer domesticus</i>	x	x	x	x	x	x	x	x	x	x	x	x
Bobolink, <i>Dolichonyx oryzivorus</i>	--	--		--	--		x	x		x	x	
Meadowlark, <i>Sturnella spp.</i>	x		x	x	x	x	x	x	x	x	x	x
Eastern meadowlark, <i>Sturnella magna</i>	--	--		x	x		--	--		x	x	x
Western meadowlark, <i>Sturnella neglecta</i>	--	--		x	x		--	--		x	x	
Yellow-headed blackbird, <i>Xanthocephalus xanthocephalus</i>	--	--		--	--		--	--		x		
Redwinged blackbird, <i>Agelaius phoeniceus</i>	*				x	x	x	x	x	x	x	x
Orchard oriole, <i>Icterus spurius</i>	--	--		--	--		x	x	x	x	x	x
Baltimore oriole, <i>Icterus galbula</i>	--	--		--	--		x	x	x	x	x	x
Rusty blackbird, <i>Euphagus carolinus</i>	--	--			x	--	--	--		--	--	--
Brewer's blackbird, <i>Euphagus cyanocephalus</i>	--	--		--	--		--	--		x		
Common grackle, <i>Quiscalus quiscula</i>	--	--			x	x	x	x	x	x	x	x
Brown-headed cowbird, <i>Molothrus ater</i>	--	--			x	x	x	x	x	x	x	x
Scarlet tanager, <i>Piranga olivacea</i>	--	--		--	--		x	x		x		x

Table 55.—Continued

SPECIES	WINTER						SUMMER					
	1906-07			1956-57 and 1957-58			1907 and 1909			1957 and 1958		
	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern	Northern	Central	Southern
Summer tanager, <i>Piranga rubra</i>							*	x				x
Cardinal, <i>Richmondia cardinalis</i>		x	x	x	x	x		x	x	x	x	x
Rose-breasted grosbeak, <i>Pheucticus ludovicianus</i>							x	x		x	x	
Blue grosbeak, <i>Guiraca caerulea</i>											*	x
Indigo bunting, <i>Passerina cyanea</i>							x	x	x	x	x	x
Dickcissel, <i>Spiza americana</i>							x	x	x	x	x	x
Purple finch, <i>Carpodacus purpureus</i>			x		x							
American goldfinch, <i>Spinus tristis</i>	x	x	x	x	x	x	x	x	x	x	x	x
Rufous-sided towhee, <i>Pipilo erythrophthalmus</i>			x		x	x	x	x	x	x	x	x
Savannah sparrow, <i>Passerculus sandwichensis</i>				x		x	x	x		x		
Grasshopper sparrow, <i>Ammodramus savannarum</i>							x	x	x	x	x	x
Le Conte's sparrow, <i>Passerherbulus caudacutus</i>						x						
Henslow's sparrow, <i>Passerherbulus henslowii</i>								x		*	x	
Vesper sparrow, <i>Poocetes gramineus</i>							x	x		x	x	x
Lark sparrow, <i>Chondestes grammacus</i>							x	x	x	x	x	
Bachman's sparrow, <i>Aimophila aestivalis</i>									x			x
Slate-colored junco, <i>Junco hyemalis</i>	x	x	x	x	x	x						
Tree sparrow, <i>Spizella arborea</i>	x	x	x	x	x	x						
Chipping sparrow, <i>Spizella passerina</i>							x	x	x	x		x
Field sparrow, <i>Spizella pusilla</i>			x	x		x	x	x	x	x	x	x
Harris' sparrow, <i>Zonotrichia querula</i>					x							
White-crowned sparrow, <i>Zonotrichia leucophrys</i>					x							
White-throated sparrow, <i>Zonotrichia albicollis</i>			x			x						
Fox sparrow, <i>Passercella iliaca</i>					x	x						
Swamp sparrow, <i>Melospiza georgiana</i>	x		x			x		*		x		x
Song sparrow, <i>Melospiza melodia</i>	x	x	x	x	x	x	x	x		x	x	x
Lapland longspur, <i>Calcarius lapponicus</i>	x			x	x	x						
Smith's longspur, <i>Calcarius pictus</i>				x								
Snow bunting, <i>Plectrophenax nivalis</i>	x											

accidental occurrence within the state; about 110 species are of rare or irregular occurrence or present in the state only during spring and fall migration. Eliminating the migrants and the species of rare or accidental occurrence, we find that about 185 species of birds in the Smith & Parmelee list occur fairly regularly in the state during either winter or summer or during both seasons. This number is close to the number in our list.

During the 1906-1909 and the 1956-1958 censuses, only nine species of birds, bobwhite, mourning dove, yellow-shafted flicker, downy woodpecker, horned lark, blue jay, crow, house sparrow, and American goldfinch, were recorded in all years and zones in both winter and summer. In

addition, chickadees, which were not identified to species, were recorded in all zones in all census years.

Species recorded in all years and zones in summer and in one or two, but not all three, zones in winter were the sparrow hawk, killdeer, red-headed woodpecker, robin, bluebird, loggerhead shrike, red-winged blackbird, grackle, cowbird, towhee, and field sparrow. In addition, meadowlarks, which were not identified to species, were seen in all zones in summer and in a number of zones in winter.

Species recorded in all years and zones in winter and in one or two, but not all three, zones in summer were the red-bellied woodpecker, tufted titmouse, white-breasted nuthatch, cardinal, and

song sparrow. In addition, the red-tailed hawk and hairy woodpecker were recorded in a high percentage of years and zones in both summer and winter.

Species recorded in all years and zones in summer only were the green heron, upland plover, yellow-billed cuckoo, chimney swift, eastern kingbird, crested flycatcher, phoebe, wood pewee, barn swallow, house wren, catbird, brown thrasher, red-eyed vireo, yellowthroat, orchard oriole, Baltimore oriole, indigo bunting, dickcissel, and grasshopper sparrow.

Species recorded in all years and zones in winter only were the junco and tree sparrow.

Avifaunal Differences Between Censuses

Of the 177 species of birds recorded in the two census periods, 104 appear on the lists for both periods, table 55. Fourteen species identified in 1906–1909 were not identified in 1956–1958.

Species recorded in 1906–1909 but not in the later series of censuses were the lesser scaup, prairie chicken, sora, woodcock, least flycatcher, yellow-bellied flycatcher, Swainson's thrush, Swainson's warbler, magnolia warbler, chestnut-sided warbler, and palm warbler, all in summer; and the golden eagle, bald eagle, and snow bunting, all in winter. Seven of these species were late spring migrants. The golden eagle, bald eagle, sora, woodcock, Swainson's warbler, and snow bunting are either uncommon or have such specialized habitat requirements that their appearance on the 1906–1909 list but not on the 1956–1958 list does not necessarily imply a population change.

The prairie chicken was recorded for both summers in the early census and not at all in the later series. The population changes in this species have been studied by Yeatter (1943).

Fifty-nine species of birds were identified in 1956–1958 but not in 1906–1909. Included in this group were three introduced species, the ring-necked pheasant, gray partridge, and starling, which have become well established in Illinois since the time of the first surveys. Another introduced species, the rock dove, was not recorded in 1906–1909. This dove was so closely associated with human habitations

at the time of the early study that it was considered to be a domestic species and therefore was not censused.

Native species not listed in 1906–1909 but listed in 1956–1958 (probably because between the two census periods they had increased in number or distribution in the state) were the common egret, little blue heron, black vulture, tree swallow, rough-winged swallow, Bell's vireo, prairie warbler, western meadowlark, yellow-headed blackbird, and Brewer's blackbird.

The majority of species listed in 1956–1958 but not in 1906–1909 were marsh or forest species. Their absence from the early list probably reflects only the fact that little acreage of marsh and forest was censused in 1906–1909. Species in this category were the horned grebe, least bittern, American bittern, mallard, black duck, blue-winged teal, wood duck, Cooper's hawk, Virginia rail, common gallinule, American coot, common snipe, black tern, horned owl, saw-whet owl, whip-poor-will, pileated woodpecker, yellow-bellied sapsucker, long-billed marsh wren, hermit thrush, blue-gray gnatcatcher, ruby-crowned kinglet, yellow-throated vireo, worm-eating warbler, cerulean warbler, yellow-throated warbler, pine warbler, ovenbird, Kentucky warbler, and hooded warbler.

Other species that were not listed in 1906–1909 and that represent specialized habitat situations not widely covered in the early surveys were the blue goose, Canada goose, herring gull, and ring-billed gull.

Certain species recorded in 1956–1958 but not in 1906–1909 occur either rarely or erratically in the state in summer or winter; hence, we would not necessarily expect to encounter them in both surveys, or in either. In this category were the short-eared owl, water pipit, Sprague's pipit, cedar waxwing, northern shrike, rusty blackbird, blue grosbeak, Le Conte's sparrow, Harris' sparrow, white-crowned sparrow, and Smith's longspur.

Annotated List of Common Species

Most of the species that make up the bulk of the bird population of Illinois are discussed in detail in the following pages. Some of the important forest species are not included because only limited

population data for the forest habitat were available from the 1907-1909 censuses.

The population figures presented in this section were derived from density data for all habitats censused in 1906-1909 and 1956-1958. Not all of these population figures agree with data in habitat tables 4-54. The data in the tables refer only to fields or blocks of habitat, whereas the figures in the species accounts include edge acreage as well as fields or blocks. For example, the sparrow hawk was not included in table 15 because it was not seen in fields of ungrazed grassland; however, ungrazed grassland is listed as a favored habitat in the species account of the sparrow hawk because this species was found in an edge situation, that is, grassland along roadsides.

Turkey Vulture.—In summer, the turkey vulture was recorded in both the central and southern zones of Illinois, but, in winter, it was found only in the southern zone. The summer data on this species present a paradox, suggesting that after 1909 there was a slight increase in the central zone population and a marked decrease in the southern zone population. We estimate that in 1907-1909 there were less than 7,000 turkey vultures (breeding population) in the central zone, while in the southern zone the populations numbered about 76,000 birds in 1907 and 43,000 in 1909. By 1957-1958, there were about 10,000 vultures in the central zone and only 15,000-16,000 in the southern zone.

Range extension in a given species is often associated with population increase, but, in the turkey vulture, range extension appeared to be associated with thinning of the population. Figures for the early censuses should be considered minimal because of the small acreage of forest (primary nesting habitat) censused. According to the census data, vultures are likely to be encountered in almost any Illinois habitat. In 1907-1909, most vultures seen were in pastureland; this finding reflected, in part, the large acreage of pastureland covered.

Winter data, as well as summer data, indicate a population decline in this species. In 1906-07, turkey vultures wintering in Illinois were concentrated in the southern zone, particularly in forest and

pastureland, where the estimated population was about 690,000 vultures—a population far exceeding the entire state population in summer. Though we saw turkey vultures in the winters of 1956-57 and 1957-58, none came within the census transects, and we judge that the winter population in those years was slightly less than the summer levels.

Weather may have had a profound effect on the winter populations of vultures, both in 1906-07 and in the later years. The winter of 1906-07 was unseasonably warm and wet, conditions that may have favored a high winter population. In both 1956-57 and 1957-58, the early part of the winter was unseasonably warm, but, in January, temperatures fell sharply, and the middle and late parts of winter were unusually cold. The cold may have pushed vultures to wintering grounds farther south. Despite the weather differences between the winter of 1906-07 and the winters of 1956-57 and 1957-58, the difference in vulture populations between the two census periods was so great that we feel the winter data corroborated the conclusion, from summer data, that the turkey vulture population in Illinois was reduced greatly between 1909 and 1956.

We can only speculate as to the cause of the reduction. The primary nesting habitat (forest) actually increased slightly in acreage after 1909, but a favored foraging habitat, pasture, was greatly reduced. The concurrent spreading and thinning of the population may be related to availability of food, and this, in turn, may be related to man's changing practices in livestock management.

Red-Tailed Hawk.—The Forbes-Gross strip census method is not well suited for censusing hawks. While census takers are likely to see hawks, wary species such as the birds of prey are very unlikely to come within the census transect lines. Our population figures for such species should be considered minimal; they are useful primarily for comparisons within this study.

The red-tailed hawk was seen in a broad variety of habitats throughout the state. It was seen within the census transects chiefly in woods and shrubby forest edge, probably because reduced visibility in these habitats permitted the census

takers to come within sight of the birds, and also because red-tails were more prone to approach census takers in or near the nesting habitat than in other areas. Specific population figures based on the censuses are questionable, but a few generalizations may be derived from them.

Despite the large acreage of forest nesting habitat in southern Illinois, the summer population of the red-tail in the southern zone was decidedly low by comparison with populations in the central and northern zones. We estimate that the red-tail population in 1957 and 1958 numbered about 25,000 birds in each of the two zones farther north, but less than 15,000 in the southern zone. The 1958 statewide population was well below the 1957 level. Because relatively little forest was censused in the summers of 1907 and 1909, comparisons of breeding populations of the red-tail in the two study periods are not warranted. Acreages of winter habitats censused in the two periods were nearly equal.

Winter populations of the red-tailed hawk tended to be lower than summer populations in the northern and central zones of the state but higher than summer populations in the southern zone. This pattern followed the generalized picture of seasonal shift in the Illinois bird population, in which southern zone populations increased from summer to winter while populations to the north decreased. The census data indicated that the winter population of the red-tail in 1906-07 was much higher than that in either 1956-57 or 1957-58. We estimated that about 90,000 red-tails wintered in southern Illinois in 1906-07; the 1956-57 and 1957-58 winter populations in this zone were about 35,000 and 19,000, respectively. Christmas count data presented by Graber & Golden (1960:13) indicated that the 1906-07 population in central Illinois, at least, was above average.

Sparrow Hawk.—The sparrow hawk was encountered throughout the state both summer and winter in all zones, but the census data indicated that there were some marked changes in the distribution pattern of this falcon between 1909 and 1956. In 1907-1909, the bulk of the state breeding population was in the southern zone, while, in 1957-58, most of the population

was in the central (particularly) and northern zones of the state.

This species had a broad ecological distribution, but ungrazed grasslands (mean density: 1.2 sparrow hawks per 100 acres in 1957-1958) and fallow fields (1.1 per 100 acres in 1907-1909) were by far the most favored foraging habitats in summer. Other important habitats (pastures, fields of mixed hay, and cornfields) had densities of not more than 0.5 sparrow hawk per 100 acres.

There was an apparent marked reduction in the statewide population of the sparrow hawk between 1909 and 1957. The change in the southern zone was particularly marked.

The summer populations of the sparrow hawk in Illinois numbered about 90,000 birds in 1907 and 197,000 in 1909; in each of these years, about 70 per cent of the state population was in the southern zone. The difference in population between the two years was consistent from zone to zone; that is, in each zone the 1909 population was higher than the 1907 population. In 1957 and 1958, summer populations (maximum estimates) of the sparrow hawk in Illinois were 33,000 and 78,000, respectively. In each of these years, about 65 per cent of the Illinois population was in the central zone, and the southern zone population was negligible.

The drastic reduction in acreage of pasture in southern Illinois may have contributed to the decline of the population. At the time of the early censuses, pastureland characteristically contained widely scattered, large trees that may have offered nesting cavities for the sparrow hawk. In recent years, farmers have become less tolerant of trees at the margins of their cultivated lands. Such trees are ideal nesting sites for the sparrow hawk, and their removal was detrimental to the bird. The increase in forest acreage in Illinois since 1907 would seem to have been more of a hindrance than a help to the sparrow hawk, which requires open foraging areas. Presumably, the sparrow hawk could compete with most other species of cavity-nesting birds, but, by sheer force of numbers, the introduced starling may have had a depressive effect on the sparrow hawk population.

Winter data, as well as summer data,

indicated a decline in sparrow hawk numbers between the two census periods. In winter of both census periods, the population was largely concentrated in the southern and central zones. Favorite foraging habitats of the sparrow hawk in winter were cornfields (stubble or mechanically harvested), hayfields, small grain stubble, and pastures, all of which had densities of about 1 sparrow hawk per 100 acres in southern Illinois.

In 1906-07, approximately 135,000 sparrow hawks were wintering in Illinois. About 81 per cent of the winter population was in the southern zone. In the winters of 1956-57 and 1957-58, populations of the sparrow hawk were estimated to have numbered respectively 60,000 and 54,000 individuals; between 60 and 70 per cent of the state population was in the southern zone. Between 1907 and 1957, the summer (June) and winter (January) populations of the sparrow hawk showed about the same percentage of decline (60 per cent). The difference between the minimum 1907-1909 population (90,000) and the maximum 1957-1958 population (78,000) represented a decrease of about 13 per cent.

Bobwhite.—Of the four galliform birds (prairie chicken, bobwhite, gray partridge, and ring-necked pheasant) recorded in the census strips, the native bobwhite was the most widely distributed and abundant. The strip census method, intended primarily for censusing songbirds, is a poor method for censusing game birds.

Quantitative data on bobwhite populations were highly variable in both census periods, but populations were consistently highest in the southern zone, diminishing progressively to the north. For example, in 1909, summer population densities for the quail in pastureland were about 6.8 birds per 100 acres in the southern zone, 5.2 in the central, and 1.0 in the northern.

Accompanying the progressive north to south increase in bobwhite numbers was a parallel increase in ecological distribution; in the southern zone, bobwhites were counted in virtually every type of habitat but urban areas. Habitat preference of the bobwhite appeared to have been similar in 1907-1909 and 1957-1958. The most consistently favored summer habitats were shrubbery of all types, orchards, hayfields,

ungrazed grasslands, and pasture. Densities of bobwhite populations in various summer habitats in southern Illinois in 1957-1958 were 137.0 birds per 100 acres in hedgerows, 45.0 in edge shrubs, 12.0 in mixed hay (3.3 in 1907-1909), 6.4 in orchards (8.8 in 1907-1909), 5.6 in ungrazed grassland (4.8 in 1907-1909), 5.0 in pastures (5.1 in 1907-1909), 4.6 in shrub-grown areas (8.0 in 1907-1909), 3.5 in red clover (7.7 in 1907-1909), 2.2 in fallow fields (2.5 in 1907-1909), 1.5 in wheat (in 1907-1909, 4.2 in wheat and 5.5 in oats), 1.2 in forest, and 0.8 in corn (0.4 in 1907-1909). There were no consistent differences in density between 1907-1909 and 1957-1958; densities in grassland habitats in the two study periods were roughly comparable.

From census data and crop acreage statistics, we estimated that the June population of the bobwhite in the southern zone was about 446,000 birds in 1907 and 643,000 in 1909. A difference in population density in these two years was expressed in almost every habitat in both the southern and central zones, and the difference was even more striking in the central than in the southern zone (central zone estimates: 53,000 birds in 1907; 169,000 in 1909). For the northern zone, the 1909 estimate was about 30,000 birds (no northern zone data are available for 1907).

In terms of numbers and geographic distribution, the summer quail population appears to have changed little since the first study period. The statewide population was at least 500,000 birds in 1907 (1907 data lacking for northern zone) and 842,000 in 1909; in these years, about 80 per cent of the state population was concentrated in the southern zone and only about 4 per cent was in the northern. In 1957, the estimated population was about 599,000 bobwhites, 80 per cent of which were in the southern zone and only 6 per cent in the northern zone. Annual fluctuations were notable at the time of the second study period, and the 1958 state population was up to at least 662,000 birds. The population increase in the state between 1957 and 1958, like that in the central and southern zones between 1907 and 1909, was consistent from zone to zone and from habitat to habitat.

While the numbers and geographic distribution of the bobwhite were about the same in the two study periods, the species has recently faced some noteworthy ecological changes. Grassland pasture, probably the most important single summer habitat in 1907–1909, had decreased by 1957 to less than one-third of its former area. With this change, hayfields, which increased in acreage, probably became the primary summer habitat for the bobwhite. Our population estimates, for both the early and recent census years, probably slighted the marginal or edge habitats such as roadsides and hedgerows. Some of the unaccounted acreage for the state (about 2,000,000 acres not accounted for in 1907–1909 and 3,000,000 in 1957–1958) may represent such high-density quail habitats.

The quail populations were much larger in winter than in early summer (all census years) and shifted more to woody habitats, fallow fields, and hayfields. Small grain fields (stubble) were important winter habitats; pastureland, even in 1906–1907, was less important in winter than in summer. In 1906–07, when corn was hand picked, bobwhites frequented this cornstalk habitat, particularly in southern Illinois; changes in harvesting methods virtually eliminated this special habitat.

The January, 1907, population of quail in the southern zone was estimated to be about 1,892,000 birds. The central zone had about 124,000 bobwhites and the northern zone 66,000, making a total of about 2,082,000 in the state. In the winter of 1956–57, the state quail population numbered about 1,773,000 birds; the number was down to 599,000 by June, 1957, up to 2,235,000 in January, 1958, and down to 662,000 in June, 1958. The amount of fluctuation was about the same in the two study periods. As quail numbers are probably at a peak in late summer and minimal in spring, our figures do not represent maximum annual fluctuations. The reader should bear in mind that, for the quail, the strip census method may be more effective in winter than in summer; this difference would tend, of course, to accentuate the difference between our winter and summer estimates of population. The figures imply that the mortality rate of quail between January

and June is high (60 and 68 per cent, respectively, in 1957 and 1958) and that good production of young in one nesting season does not necessarily increase the nesting population in the following year. There are, apparently, differences in rates of production and mortality between areas with high and areas with low population density. In the early census period, the ratio between winter (1906–07) and summer (1907) populations was about 4:1 in southern Illinois and 3:1 in central Illinois; in the later census period, the ratio between winter (1957–58) and summer (1958) populations was 3:1 in southern Illinois and 2:1 in central Illinois. In all years, both production and mortality were relatively higher in the southern zone (high-density area) than in the central zone (low-density area). These characteristics tend to make the total Illinois quail population unchanging from year to year and, coupled with the subtle nature of the habitat changes, help to account for similarities between the 1906–1907 and the 1956–1958 figures.

Killdeer.—Only five species of shorebirds, killdeer, American woodcock, common snipe, upland plover, and spotted sandpiper, were encountered in the censuses. Of these, the killdeer and upland plover were common enough to warrant special discussion.

In summer, the killdeer was counted in all zones as well as all years but, in winter, it was detected only in the southern zone and only in very small numbers. Though the killdeer occurred throughout the state in summer, the density of killdeer populations varied from zone to zone in an interesting and unexplained ecological pattern. Cornfields provided a relatively high-density habitat in the southern zone (4.3 birds per 100 acres in 1957–1958; 4.6 in 1907–1909), but a low-density habitat in the central zone (0.2 in 1957–1958; 0.3 in 1907–1909). Conversely, pastureland had higher killdeer populations in the central zone (1.2 birds per 100 acres in 1957–1958; 1.8 in 1907–1909) than in the southern zone (0.8 in 1957–1958; 0.7 in 1907–1909). In this ecological variation, northern zone populations tended to follow central zone populations.

The killdeer is one of the species of

birds that would seem to be favored by row-crop agriculture. It favors habitats with large amounts of bare ground, and population densities for this species tend to fall as vegetative cover increases in a habitat. Densities of killdeer populations in various habitats in southern Illinois in 1957-1958 were 10.6 birds per 100 acres in marshland (dry margins), 10.0 in plowed ground (2.2 in 1907-1909), 8.2 in alfalfa, 4.3 in corn (4.6 in 1907-1909), 4.1 in soybeans (7.7 in beans in 1907-1909), 0.8 in pasture (0.7 in 1907-1909), 0.4 in fallow fields (0.3 in 1907-1909). In 1957-1958, mixed hay and red clover had negligible populations of killdeers in the southern zone; in the central zone, red clover had 2.2 birds per 100 acres (2.1 in 1907-1909), and, in the northern zone, mixed hay had 2.2 birds per 100 acres. Generally in hayfields, the killdeer favors spots where the vegetation is thin and low; thus, the population in some hayfields may be high. The best of the habitats, as shown by high population, were the marshes (principally the dry margins) in northern Illinois, where the density was 11.5 birds per 100 acres. Sand prairie in the northern zone had 2.4 killdeers per 100 acres. All of the above-mentioned habitats were probably both nesting and foraging sites for killdeers.

There is no indication that habitat preferences of the killdeer changed between 1909 and 1957. Population densities for given habitats were similar in the two periods. The census data indicated a northward trend in the state killdeer population between 1909 and 1957. In many habitats, population densities in the northern zone increased during this period. In pastures of this zone, for example, there were 1.0 killdeer per 100 acres in 1909 and 2.9 killdeers per 100 acres in 1957-1958; in cornfields, 0.0 in 1909 and 2.6 in 1957-1958; in mixed hay, 0.0 in 1909 and 2.2 in 1957-1958. In June, 1909, the southern zone of Illinois had an estimated population of about 339,000 killdeers (83 per cent of the state population); the population diminished rapidly and progressively to the north, and the northern zone had only about 14,000 killdeers (less than 4 per cent of the state total). In 1957 and 1958, populations in the northern zone were, respectively, 119,000 (36 per cent of

state total) and 125,000 (24 per cent of state total).

By our estimates, June populations of the killdeer in the state numbered about 406,000 birds in 1909, 326,000 in 1957, and 524,000 in 1958. Year-to-year variation in the breeding population, obviously, was high. Because the killdeer nests on the ground in a minimum of cover, it may be particularly influenced by weather during the nesting season (April-June).

By winter of each year, migration has carried most of the killdeer population south of Illinois. A few killdeers may be found even in the northern zone in winter, but populations north of the southern zone are usually negligible. With the change in season, there is also a habitat change, and, in both the early and recent winter censuses, the killdeer was found to favor clover and alfalfa fields, almost to the exclusion of other habitats. The 1906-07 and 1956-57 winter populations of the killdeer were comparable (about 157,000 birds each winter). By comparison, the 1957-58 population was very low (about 11,000 birds). The winter census of 1957-58 was conducted about 3 weeks later in the year than the censuses of 1906-07 and 1956-57. Southern Illinois experienced unusual cold in 1957-58, which probably pushed the killdeer population farther south than usual.

Upland Plover.—The upland plover was recorded throughout the state in summer; highest frequencies were in the central and northern zones.

This plover was found in a variety of open-field habitats—pasture, hayfields, fallow fields, small grain, corn, and soybeans; the greatest densities were in pastureland and hayfields (especially red clover).

Densities of upland plover populations were, in certain habitats, roughly comparable in the northern and central zones and conspicuously lower in the southern. Densities in Illinois pastureland in 1907-1909 were 3.1 birds per 100 acres in the northern zone, 2.0 in the central, and 0.3 in the southern. Population densities of the upland plover in various habitats of the northern and central zones (combined) in 1957-1958 and 1907-1909 were 7.5 birds per 100 acres in red clover fields (22.5 in 1907-1909), 2.2 in mixed hay and alfalfa (1.3 in 1907-1909), 0.7 in

pastures (2.4 in 1907-1909), 0.8 in small grain fields (0.1 in 1907-1909), and 0.5 in corn (0.5 in 1907-1909).

Both pasture and hayfields were recorded as nesting habitats of the upland plover; the other habitats listed probably represented only foraging areas. The ecology of the species seems to be changing. The density data suggest that pasture (a declining habitat) is becoming less important to the plover, while mixed hay and alfalfa are becoming more important. In the southern zone, alfalfa was the most important plover habitat in the second census period.

While the range of the upland plover in the state did not change between 1909 and 1957, the distribution of the population changed considerably. In 1907-1909, about half (140,000 birds) of the state population (283,000 birds) was found in the northern zone, and the remainder was fairly evenly divided between the central and southern zones. By 1957-1958, the state population (208,000 in 1957; 177,000 in 1958) had declined; in both years, most (60-80 per cent) of the population was in the central zone, and less than 15,000 birds of this species were in the southern zone.

The decline of the state population and the shift of the population toward central Illinois may be related to habitat changes. The great loss in pastureland acreage was probably a primary factor in the decline. The density data suggest that the quality of pastures (as plover habitat), as well as the acreage, declined. The relative increase of the plover in the central zone reflects, to some extent, the increase of red clover acreage in this zone after 1909.

Mourning Dove.—In all census years, the mourning dove occurred throughout the state in both summer and winter; the winter populations tended to be concentrated in the southern zone.

No species of bird in the state had a broader ecological distribution than the mourning dove, which was found nesting and foraging in virtually all terrestrial, shrub, and arboreal habitats. Dove populations were highly variable in density from habitat to habitat and from zone to zone. The 1957-1958 densities of summer dove populations in shrub-grown areas were 11.1 birds per 100 acres in

southern Illinois, 12.2 in the central zone, and 15.5 in the northern. By contrast, densities in soybean fields were 6.6 per 100 acres in the southern zone, 4.3 in the central zone, and 3.6 in the northern.

Rated on the basis of population density (all census years considered), habitats most favored by the mourning dove in summer were marginal or edge shrubbery, hedgerows, sweet clover fields, prairie or ungrazed grasslands, orchards, marshes, urban residential areas, and fallow fields.

Average densities of mourning dove populations in various summer habitats in the state in 1957-1958 were 142.5 birds per 100 acres in edge shrubs, 97.6 in hedgerows, 39.5 in sweet clover, 38.0 in ungrazed grassland (10.7 in 1907-1909), 32.9 in orchards (46.5 in 1907-1909), 31.6 in fallow fields (10.6 in 1907-1909), 29.7 in marshes, 28.6 in urban and rural residential areas (1.8 in 1907-1909), 15.5 in red clover (9.3 in 1907-1909), 12.0 in shrub-grown areas (17.3 in 1907-1909), 7.5 in plowed fields (14.1 in 1907-1909), 6.0 in wheat fields (13.8 in 1907-1909), 4.8 in alfalfa, 4.6 in mixed hay (6.2 in 1907-1909), 4.5 in soybean fields, 3.6 in forest (10.2 in 1907-1909), 2.6 in pastures (5.4 in 1907-1909), 2.6 in cornfields (4.4 in 1907-1909), and 1.3 in oat fields (2.9 in 1907-1909). A small acreage of savanna-type habitat had about 11 doves per 100 acres.

Harvesting of crops greatly alters the ecological distribution of the dove, for this species tends to concentrate in fields where the crops have been cut. For example, in 1907-1909 in southern Illinois, there were 74 doves per 100 acres in cut wheat fields and only 17 per 100 acres in uncut wheat. Similarly, in 1957-1958 in the northern zone, there were 11 doves per 100 acres in mowed hayfields and 3.6 in uncut hayfields.

Certain apparent habitat preferences of the mourning dove in summer are noteworthy. The high density of birds at marshes may well represent concentrations of doves seeking water. The fallow-field habitat was genuinely favored by the dove, and our experience showed this was the open-field type that was most used for nesting. Clover fields seem to have been much favored over mixed hay and alfalfa fields. Most of the doves found in the

hayfields, particularly those in harvested hayfields, were probably foraging. Wheat, generally a very poor bird habitat, had relatively high populations of doves. Hanson & Kossack (1957:178; 1963:92) have pointed out the importance of wheat in the mourning dove diet. In 1907-1909, rye was a much-favored habitat in southern Illinois—probably even more than wheat—but the sample was too small to give a valid density figure. Oat fields were the poorest of the dove habitats in all zones of the state. Open space appears to be an important characteristic of all of the dove habitats with high population density; the difference between dove populations in urban areas (high density) and those in forests (low density) may in part reflect this characteristic.

The density figures presented above represent mostly, but not solely, adult populations. While we did not include identifiable juveniles in the calculations, some well-grown birds of the year were surely counted as adults. The figures include both nesting and foraging doves in each habitat. In the censuses of 1907-1909 and 1957-1958, several ground nests of the mourning dove were found in open-field habitats, but we have no way of knowing what per cent of the population found in open fields represented nesting birds. We judge that only a few habitats (shrub, orchard, urban area, and fallow field) have high nesting densities of the mourning dove, and these habitats represent a small per cent of the land acreage of the state.

In all but four of the summer habitats (fallow field, ungrazed grassland, red clover, and urban and rural residential areas), densities averaged higher in 1907-1909 than in 1957-1958. There is evidence of a northward shift in the dove population between 1909 and 1957. In 1907-1909, population densities of the mourning dove in several habitats (pasture, prairie, orchard, corn, and plowed fields) tended to be highest in the southern zone and lowest in the northern; in 1957-1958, dove populations in some of these habitats showed highest densities in the northern zone, lowest in the southern. For example, in pastureland in 1907-1909 there were about 2.1 doves per 100 acres in the northern zone, 5.0 in the cen-

tral, and 6.3 in the southern, but in 1957-1958 densities were 2.9 in the northern zone, 2.9 in the central, and 1.7 in the southern. Of all the habitats, only orchard was consistent in having highest densities in the southern zone in all years.

Some of the patterns of summer distribution seemed contradictory. Why should orchards have had highest concentrations of dove populations in the southern zone, while shrub and urban residential areas had highest concentrations in the northern zone? Some distribution patterns may have been related to habitat availability. For instance, shrub acreage was low in the northern zone, and doves may have tended to pack the available area of this excellent nesting habitat. The limited acreage of shrub areas in northern Illinois may also have accounted for the high densities of dove populations in the northern urban areas.

Within a given habitat or a particular geographic area, mourning dove populations may fluctuate greatly from year to year. Hanson & Kossack (1963:115-7) reported great year-to-year fluctuations in the habitats and area they studied. In the statewide and zonewide populations of the periods reported here, we found that population fluctuations in the mourning dove were remarkably small in comparison with population fluctuations in many other species.

Our estimates of the statewide mourning dove populations were as follows: 2,438,000 in 1909 (about 2,500,000 in 1907, as estimated from central and southern zone data), 2,000,000 in 1957, and 2,000,000 in 1958. Such small fluctuations were, perhaps, to be expected in a broadly distributed species, which may suffer losses in one zone or habitat and balance them by gains in another zone or another habitat. Because dove populations varied little from one census year to the next, we believe that there was an actual decline in the state population between the two census periods amounting to about 19 per cent of the 1907-1909 level. Most of the loss appears to have been in the southern zone population, which dropped from about 1,500,000 birds in 1907-1909 to about 1,100,000 in 1957-1958. The 1957-1958 dove populations in the northern zone (about 400,000

birds) and the central zone (about 500,000 birds) were almost the same as the 1907-1909 populations in these zones.

Winter populations of the mourning dove in the northern and central zones were sparse in all census years; the southern zone had more than 90 per cent of the state population in winter.

Some noteworthy changes took place between 1906-07 and 1956-57 in the winter dove population and its ecology. In 1906-07, most of the wintering doves of the state were found in one habitat, cornstalk (picked corn) fields, where population densities were 0.7 bird per 100 acres in the northern and central zones and 35.6 per 100 acres in the southern zone. Changing agricultural methods virtually eliminated this preferred habitat. The agricultural replacement for cornstalk habitat was the mechanically picked cornfield, which had average densities, in 1956-57 and 1957-58, of 0.3, 0.5, and 3.7 doves per 100 acres in the northern, central, and southern zones, respectively. Population densities in other winter habitats in the southern zone (1956-57 and 1957-58 average) were 103.8 doves per 100 acres in shrubs, 23.1 in bean stubble, 9.0 in ungrazed grass, 8.0 in forest, 1.9 in fallow fields, 1.3 in hay, 1.0 in wheat, and 0.8 in small grain stubble. The most consistently used habitats were forest and cornfields in the northern and central zones and shrub-grown areas and cornfields in the southern zone.

The mourning dove apparently wintered farther north in much higher numbers in 1956-1958 than in 1906-07. In 1906-07, a notably mild winter, the state dove population (all habitats) numbered about 350,000 birds; the lower population of the two later censuses (1957-58) was about 1,200,000 birds, despite the fact that weather conditions were more adverse to wintering doves in 1957-58 than in 1906-07. In both 1906-07 and 1957-58, dove populations in the northern and central zones (combined) numbered less than 50,000 birds, a negligible part of the state total. The increase noted above was primarily in the southern zone of the state.

Year-to-year variation in the winter dove population was high, and the difference between the 1956-57 and 1957-58 populations warrants discussion. State

populations in 1956-57 and 1957-58 numbered about 2,000,000 and 1,200,000 birds, respectively. A factor that may have had some bearing on the reduced number in 1957-58 was the unusual and prolonged cold during the fall dove migration season (1957), which may have effected a more extensive evacuation of doves from the state. In addition, our census schedule was late in 1957-58 (running into February), and extreme cold in January and February may have pushed doves farther south. Censuses conducted in late December, 1956, and early January, 1957, when mild winter conditions prevailed, showed a dove population for the northern and central zones of about 130,000 birds. By contrast, the populations in these zones, following prolonged cold in January and early February, 1958, were negligible. These data, coupled with the great increase in the population of the southern zone between the winters of 1906-07 and 1956-57, indicate that the northern edge of dependable winter range for the mourning dove in Illinois is south of latitude 40 degrees.

The increase that occurred in the winter dove population of the southern zone between 1906-07 and 1956-57 is puzzling, particularly in view of the apparent decline in the breeding population. The change follows a pattern of northward range extension which we can observe in many species of birds. Regardless of the underlying cause of the range extension, it is conceivable that the populations involved may tend to concentrate, that is, increase where some climatic or other barrier delimits the range extension. Such a mechanism may be involved in the increase in the winter dove population of Illinois.

Because nesting populations of the mourning dove have low densities in open-field habitats, intensive cultivation, especially when accompanied by removal of such high-density dove habitats as edge shrubs, hedgerows, and orchards, is detrimental to the dove. Activities of the expanding human population in urban areas may compensate to some extent for the loss of nesting sites in rural areas, because plantings in residential urban areas have large dove populations. The mourning dove may, in fact, be adapting to this expanding habitat, as the early censuses

showed few doves in urban residential areas.

Cuckoos.—In all census years combined, the two cuckoos were counted in a ratio of about 14 yellow-bills to 1 black-bill.

The yellow-billed cuckoo occurred throughout the state in summer of all census years; it was most abundant in the southern zone, least abundant in the northern. In most habitats, population densities were highest in the southern zone. In edge shrubbery in 1957–1958, there were 10.0 birds per 100 acres in the southern zone and 8.4 in the northern zone.

Densities of yellow-billed cuckoo populations in various summer habitats in the southern zone in 1957–1958 were 45.7 birds per 100 acres in hedgerows, 10.0 in edge shrubbery, 3.9 in orchards (6.6 in 1907–1909), 1.6 in shrub-grown areas (12.0 in 1907–1909), 0.8 in pastures (0.2 in 1907–1909), 0.6 in forest (3.3 in 1907–1909). In 1907–1909 only, the yellow-billed cuckoo was found in residential habitat (6.0 birds per 100 acres), wheat fields (0.7), and mixed hay (0.5).

The density data suggest that the cuckoo population declined between 1909 and 1957. Our estimates of the state populations in different years were 167,000 birds in 1907, 383,000 in 1909, 92,000 in 1957, and 59,000 in 1958. The estimates indicate a notable population decrease.

Habitat changes that eliminated some of the best cuckoo nesting areas in the state undoubtedly had some effect on the cuckoo population; among these changes were the decrease in the acreage of orchards by 1958 to about one-tenth of the 1909 acreage and the destruction of many hedgerows and roadside shrubs along field boundaries. An increase in forest-edge habitat in southern Illinois compensated but little, for this had become a low-density habitat for cuckoos. Cuckoos were found in residential areas in 1907–1909 but not in 1957–1958. The difference may reflect some change in the nature of plantings near human habitations.

Chimney Swift.—In all census years, the chimney swift was found in summer throughout the state.

Before white settlement, chimney swifts probably placed their nests in hollow trees. They may still use such nesting sites, but

most of the population nests in man-made chimneys. This very specialized nesting habitat and the special feeding method of the chimney swift complicate discussion of populations of this species. In urban residential areas in 1958, we counted 24.4 swifts per 100 acres in the southern zone, 26.8 in the central zone, but only 14.4 in the northern zone. On the other hand, population densities of the swift foraging in nonurban areas tended to be highest in the northern and central zones. The urban densities were lowest where the availability of nesting sites was highest. Most of the state's urban acreage is in the northern zone (71 per cent in northern zone, 13 per cent in central zone, and 16 per cent in southern zone).

Because of its great mobility, the swift was encountered in every habitat censused. Populations were not distributed over the various habitats in proportion to the acreage distribution of the habitats. For example, cornfields comprised the largest (in terms of acreage) single habitat in the state, and the largest habitat sampled, but only about 11 per cent of the swifts counted were over cornfields; about 35 per cent were over hayfields, which had about half the acreage of cornfields.

In all census years, hayfields (various types), pasture, and fallow fields were the favored foraging habitats of the swift. Population densities of foraging swifts over hayfields of all types (an expanding habitat) were about the same (average density 3.4 birds per 100 acres) in 1957–1958 as in 1907–1909, but in pastureland (a diminishing habitat) swift numbers showed an increase between 1907–1909 (1.2 per 100 acres) and 1957–1958 (4.6 per 100 acres). These observations suggest that the swift has been consistent in habitat preferences through the years. Populations over alfalfa were comparable to those over mixed hay. Red clover and sweet clover fields were particularly favored (average density: 7.2 swifts per 100 acres); total clover acreage increased between 1909 and 1957. In other habitats, densities (all census years combined) were 1.4 swifts per 100 acres in fallow fields, 1.1 in small grain, and 0.6 in corn. We do not imply by these observations that the swift consciously chooses particular foraging habitats. The

distribution of foraging swifts probably reflects distribution of insect concentrations, which vary from habitat to habitat.

It is difficult to estimate population change, if any, in the chimney swift between 1909 and 1957. Population densities of this species in urban areas, perhaps the best guide, were 6.0 birds per 100 acres in the southern zone in 1909 and 24.4 in the same zone in 1958. Ecological changes since 1909 appear to be highly favorable to the chimney swift. With increased nesting habitat arising through urbanization, and an increase in favored foraging habitats, the swift population may increase along with the human population.

Yellow-Shafted Flicker.—Of the seven species of woodpeckers (yellow-shafted flicker; pileated, red-bellied, red-headed, hairy, and downy woodpeckers; and yellow-bellied sapsucker) found within the census strips (all years included), the flicker was the most abundant. It was counted in all zones and years, both summer and winter.

The yellow-shafted flicker was found in a great variety of summer habitats, and in all of them population densities were consistently (all census years) highest in the northern zone. Densities were slightly lower in the central zone than in the northern and fell off sharply in the southern. For example, in 1909, pastureland had 16.6 flickers per 100 acres in the northern zone, 14.9 in the central zone, but only 4.3 in the southern.

Favored summer habitats of the flicker were hedgerows, savanna-type areas, edge shrubbery, residential areas, and forest. Densities of flicker populations in various summer habitats in northern Illinois in 1957–1958 were 31.4 birds per 100 acres in hedgerows, 21.6 in savanna-type areas, 8.4 in edge shrubbery, 5.6 in residential areas (27.8 in 1909), 5.6 in forest, 3.0 in shrub-grown areas, 2.9 in pastures (16.6 in 1909), 2.2 in mixed hay (6.8 in 1909), 2.1 in fallow fields (20.6 in 1909), 1.2 in oat fields (1.2 in 1909), 1.0 in ungrazed grassland (6.8 in 1909), and 0.8 in cornfields (2.8 in 1909). (No surveys were made in northern Illinois in 1907.) Harvested hayfields and clover fields, which often have high bird populations, were apparently not attractive to flickers. In all

habitats for which we have comparative data over the entire state, population densities of the flicker were much lower in 1957–1958 than in 1907–1909.

As the density data imply, the state flicker population declined greatly between the two study periods, from about 2,279,000 birds in 1909 to 300,000 in 1957 and 225,000 in 1958. Perhaps 1909 was a bumper year for flickers. The population was lower in 1907 than in 1909; yet the central and southern zones in 1907 (no census in the northern zone that year) had about 727,000 flickers, more than twice the 1957 or the 1958 population for the entire state.

Causes for the decline in flicker numbers can only be surmised. Habitat changes probably had some effect. The flicker is not strictly a forest bird. Open fields, particularly grassland, and scattered trees for nesting sites are probably the essential habitat requirements. While Illinois contained more forest in 1957–1958 than in 1907–1909, savanna-type situations in the state probably were greatly reduced; tree removal from field edges and tillable land has recently been common practice in Illinois. Reduction of pasture acreage eliminated some nesting sites (scattered trees), as well as good foraging habitat.

The introduction of the starling may have played a very important role in reducing the flicker population. Competition among certain species for nest cavities is keen, and starlings have proved their ability to compete. Of all the Illinois picids, the flicker has been most closely associated with man and is therefore probably most in competition with the introduced bird. In the summers of 1957 and 1958, flicker populations varied from place to place in urban areas inversely with the starling populations. The change in the flicker population between 1909 and 1957 accentuated its north-south cline. The northern zone of Illinois had about 841,000 birds in 1909 and 186,000 in 1957; the southern zone had 445,000 in 1909 and less than 15,000 in 1957.

In winter, most of the Illinois flicker population was found in the southern zone. In contrast to the summer population densities, winter densities were not consistently lower in 1956–1958 than in 1906–07.

In 1906-07, the picked cornfields with stalks still standing comprised the favorite winter habitat of the flicker, as well as many other species, in southern Illinois; no other habitat boasted such a high density (7.7 flickers per 100 acres in contrast to 1.7 for corn stubble only). Other favored habitats were shrub areas, ungrazed grassland, forest, and pasture. Flicker population densities for these and other winter habitats in the southern zone for 1956-1958 were 6.0 flickers per 100 acres in hayfields (1.0 for 1906-07), 4.6 in shrub-grown areas, 3.8 in forest (2.5 for 1906-07), 2.2 in ungrazed grassland (6.6 for 1906-07), 2.0 in pasture (2.9 for 1906-07), and 2.0 in mechanically picked cornfields (for 1906-07, 1.7 in stubble and 7.7 in hand-picked fields). The corn-stalk habitat, by its attractiveness and almost unlimited availability, may have been partly responsible for low densities of the flicker in other habitats in 1906-07. Winter wheat, an ample habitat in southern Illinois, apparently was not used by the flicker, nor were fields of small grain stubble to any considerable degree.

In January, 1907, there were about 544,000 flickers wintering in the state (75 per cent in the southern zone). In January, 1957, the state flicker population numbered about 202,000 birds (85 per cent in the southern zone). As in populations of some other species, flicker populations apparently shifted southward in late winter, for in February, 1958, about 394,000 birds (96 per cent of the state population) were in the southern zone and less than 20,000 in the rest of the state.

Red-Bellied Woodpecker.—In 1907-1909, the breeding population of the red-bellied woodpecker in Illinois was virtually restricted to the southern zone, but, in 1956-1958, this species was found in all zones of the state.

The primary habitat for the red-bellied woodpecker was forest, in which summer populations were remarkably constant at about 5 birds per 100 acres in the southern zone in both the early and later census years. By 1957-1958, the central zone forests also had attained densities of about 5 birds per 100 acres, but the nesting population in the northern zone was still very sparse. Because population densities of the red-belly appeared to level off at 5

birds per 100 acres in both the southern and central zones, we believe that this figure represents a saturation level for the breeding population in this species.

Other habitats frequented by the red-belly in summer were shrub areas and grassland, especially pasture, which were probably foraging areas (usual densities: about 2 birds per 100 acres in each of these habitats).

In the winters of 1956-57 and 1957-58, the red-bellied woodpecker populations in forest increased over the summer levels in all zones of the state. From the summer density of 5 birds per 100 acres, the forest population increased by winter to 9 birds per 100 acres in the southern zone and 7 per 100 acres in the central zone. Because the red-bellied woodpecker is not a strongly migratory species, much of the winter increment probably represented local production. Both the geographical distribution (extension of the range northward) and the ecological distribution of the red-bellied woodpecker were greater in winter than in summer. Evidence of a northward extension of the population in winter was the fact that the forest population in the northern zone increased from a very sparse population in summer to about 3 birds per 100 acres in winter. Ecological extension was evident in winter when the red-belly was seen in shrub areas, fallow fields, pastures, and even row crops. Winter densities in nonforest habitats were usually 1 to 2 birds per 100 acres. The ecological extension may have represented both a wandering juvenile population and a seasonal change in foraging habits by the total population.

We estimate that the breeding population numbered about 103,000 in 1907 and 119,000 in 1909, all in the southern zone. By 1957-1958, the number of red-bellies in the state had greatly increased (to at least 198,000 in 1957 and 153,000 in 1958), with most of the population in the southern and central zones. The population will probably continue to increase in the northern zone. Because the red-bellied woodpecker is a forest species (not associated with man), it is less in competition with the starling than is the flicker.

Red-Headed Woodpecker.—In all census years, the red-headed woodpecker

was encountered throughout the state in summer, but only in the southern and central zones in winter. In 1907-1909, summer populations of the red-head were fairly uniformly distributed in the state, but, in 1957-1958, the southern zone had a negligible part of the state population. Populations of this species are notoriously variable from year to year, but, even after considering this annual variation, we believe that the red-headed woodpecker population was much higher in 1907-1909 than in the later census years.

Like the flicker, the red-headed woodpecker appeared to prefer a savanna-like situation in summer; it was found often in open fields. Favored summer habitats, in addition to savanna-type, were shrub-grown areas and forest. The red-headed woodpecker was found in virtually every habitat censused in 1907-1909, but in only a few habitats in 1957-1958. Densities of red-headed woodpecker populations in various habitats in the state in 1907-1909 were 22.1 birds per 100 acres in shrub-grown areas (1.4 in 1957-1958), 12.8 in forest (2.3 in 1957-1958), 5.8 in orchards, 3.8 in fallow fields, 3.7 in red clover (0.7 in 1957-1958), 3.6 in pastures (0.2 in 1957-1958), 3.5 in ungrazed grassland (2.1 in 1957-1958), 2.7 in plowed fields, 1.8 in residential habitat (0.6 in 1957-1958), 1.5 in wheat, 1.2 in mixed hay, 1.1 in corn (0.1 in 1957-1958), and 0.4 in oats. Savanna-like areas censused in 1957-1958 had 16.0 red-headed woodpeckers per 100 acres.

The summer populations of the red-headed woodpecker in 1957-1958 were but a small fraction of those in 1907-1909. We estimated that there were about 1,270,000 red-headed woodpeckers (breeding adults) in the state in June, 1909, but only 115,000 in 1957 and 134,000 in 1958. The 1907 population may have been under 1 million (no northern zone census in 1907), but it was still at least seven times as great as the 1957-1958 populations. The red-head and the flicker had a similar pattern of gross population reduction in the state, a reduction that was especially noticeable in the southern zone. These two species have certain habitat preferences in common; in summer, they, more than other species of woodpeckers, seek nonforest habitats. The in-

troduction of the starling and some subtle, though important, habitat changes discussed in the section on the flicker have probably had harmful effects.

The red-headed woodpecker is migratory and in winter it usually vacates the northern parts of its breeding range. In winter, forest becomes the primary habitat almost to the exclusion of other habitat types. The red-headed woodpecker in Illinois wintered farther north in 1956-1958 than in 1906-07. This northward extension may represent a trend, though the winter distribution of red-heads varies greatly from time to time and depends on availability of acorns and on other foraging conditions. In 1906-07, despite the mildness of the winter, red-heads were found in Illinois only in the southern zone, where the population numbered only 38,000 birds, mostly in forest. By contrast with the flicker, the red-head made little use of cornstalk habitat. In 1956-1958, red-headed woodpeckers were found in forest in both the central and southern zones, and state populations numbered 92,000 (72 per cent in the southern zone) in January, 1957, and 424,000 (98 per cent in the southern zone) in February, 1958. The very high winter population in the southern zone in 1958 probably represented a special concentration, the result of unusually good foraging conditions there. The central zone was virtually devoid of red-heads, and part of the concentration in the southern zone may have come from states adjacent to Illinois.

What the future holds for this species is difficult to predict. There is some evidence that red-head populations reached their lowest level before 1957 (but after 1909) and that the populations have come back slightly in recent years. With competition for nesting cavities particularly great since the introduction of the starling, a notable future increase in the red-head population seems unlikely.

Downy Woodpecker.—The downy woodpecker was encountered throughout the state during the surveys about four times as frequently, both in summer and winter, as its congener, the hairy woodpecker.

The downy woodpecker is primarily a forest species, and we can say little about

population changes, if any, between 1909 and 1957, because of the small acreage of forest sampled in summer in the early surveys. Our southern census samples indicate that the state population of the downy increased at least slightly between the two survey periods, perhaps because of the spread of forest.

The geographic and ecological distribution of the downy woodpecker in the recent surveys is of interest. In the summers 1957 and 1958, downies were found in the northern and central zones only in forest, but in the southern zone in both forest and shrub areas. Population densities indicated that central zone forests were particularly good for downies. Forest populations were 3.4 birds per 100 acres in the northern zone, 12.2 in the central, and 2.8 in the southern.

We estimated that the state breeding population of the downy was about 287,000 in 1957 and 219,000 in 1958. (Estimates of forest populations are apt to be low if based on the strip census method.) In both years, 53 per cent of the nesting population of the state was in the southern zone and about 40 per cent in the central.

The downy woodpecker is supposedly not a migratory species in Illinois. In winter, the downy population, swelled by summer production, extended into many nonforest habitats, our data showed. This ecological extension may be explained by one or more of the following: the natural overflow of a swelled population, the wandering of juveniles, or a change (from summer) in foraging habits by the total populace. Woody habitats (forest, shrubs, and orchards) had the highest population densities in winter; such open-field habitats as corn stubble, fallow fields, and pasture also harbored downy populations.

Winter population estimates of the downy woodpecker for the state were 322,000 birds in 1906-07, 506,000 in 1956-57, and 507,000 in 1957-58. These figures represented increases over the respective summer populations of about 2 to 1; the ratio was not the same in all zones. About 60 per cent of the state population was in the southern zone, only 10-15 per cent in the central zone, and 25-30 per cent in the northern zone. These figures mean that winter populations in the northern and southern zones

increased greatly over their respective summer populations, as expected, while the winter population in the central zone actually fell below the summer population there. The distribution pattern is exceedingly perplexing, but, because the pattern was consistent in all census years, we feel that it represents a genuine biological phenomenon. The data suggest that there is at least one migratory population of downies in the state; distribution, both winter and summer, in this species needs careful and detailed study.

With increased acreage of forest, and almost unlimited areas of winter forage habitats (corn, fallow fields, pasture, shrub, and forest), the future for this species looks bright.

Eastern Kingbird.—Six species of summer resident flycatchers (eastern kingbird, crested flycatcher, phoebe, Acadian flycatcher, Traill's flycatcher, and wood pewee) were encountered during the summer surveys. The eastern kingbird was fairly uniformly distributed in the three zones of the state in 1907-1909, but populations tended (all census years) to be most dense in the northern zone, least dense in the southern. For example, pastureland in 1907-1909 had 4.7 kingbirds per 100 acres in the northern zone (5.7 in 1957-1958), 3.4 in the central (1.7 in 1957-1958), and 2.5 in the southern (0.0 in 1957-1958). Populations in the southern zone were particularly low in the recent census years. In 1957-1958, shrub-grown areas had densities of 9.3 kingbirds per 100 acres in the northern zone, 8.2 in the central, and 0.8 in the southern.

The eastern kingbird occurred in all census years in virtually every summer habitat censused; particularly favored were edge shrubbery, farmyards, shrub-grown areas, savanna-type areas, and orchards. Densities of kingbird populations in various habitats in the northern zone in 1957-1958 were 33.5 birds per 100 acres in edge shrubs, 9.3 in shrub-grown areas, 7.2 in savanna-type areas, 6.2 in fallow fields, 5.7 in pasture (4.7 in 1909), 1.8 in red clover, 1.4 in both mixed hay and mowed hayfields (2.8 in 1909), and 0.3 in cornfields (1.7 in 1909). In 1907-1909, farmyards of the state had 7.3 kingbirds per 100 acres; orchards in the southern zone had 6.6 per 100 acres (3.8 in

1957-1958). Frequently used (all census years) foraging habitats in the central and southern zones were plowed fields (2.5 birds per 100 acres), oat fields (1.6), and ungrazed grassland (1.4). Population densities in favorite habitats were roughly similar in 1907-1909 and 1957-1958, but densities in marginal habitats, such as cornfields, indicated that there had been a decline in the kingbird population between 1909 and 1957.

Our estimates of the state breeding populations of this species were 662,000 in 1909 (about 650,000 in 1907, estimated from central and southern populations), 307,000 in 1957, and 226,000 in 1958. The decline was particularly striking in the southern zone, where the kingbird population fell from about 350,000 birds in 1907-1909 to less than 100,000 in 1957-1958.

Because the tyrant flycatchers are notably aggressive in competing with other species, competition would seem an unlikely factor in the decline of the kingbird. Habitat changes between 1909 and 1957 probably had a marked effect on the kingbird population. Areas of two important kingbird habitats, orchards and pastureland, were reduced tremendously. An increase in forest areas probably eliminated some kingbird habitat, and reduction in the numbers of farmsteads and hedgerows in recent years removed some prime nesting habitat. It is possible that changes in the insect fauna had an effect on the kingbird population. The fact that the 1957-1958 densities in orchards were notably below the 1907-1909 level suggests that modern methods of orchard management do not favor the kingbird. Because roadside vegetation (hedges and shrubs) provides an important habitat for kingbirds, roadside spraying with herbicides and insecticides may have played an important role in the decline.

Horned Lark.—In all census years, the horned lark was recorded throughout the state, both summer and winter, in all open-field habitats. Summer population densities for the lark were notably lower (all census years) in the southern zone than in the central and northern zones. For example, cornfields in 1957-1958 had 32.9 larks per 100 acres in the northern zone and 32.2 in the central zone, but

only 4.7 per 100 acres in the southern zone. In certain habitats, particularly hay types, there was marked difference between northern and central zone populations. In 1957-1958, population densities in alfalfa fields were 112.9 larks per 100 acres in the central zone and 11.6 in the northern; densities in red clover fields were 96.8 in the central zone and 0.4 in the northern.

Densities of horned lark populations in various summer habitats in the central zone in 1957-1958 were 149.8 birds per 100 acres in plowed fields, 112.9 in alfalfa, 96.8 in red clover, 46.6 in soybeans, 32.2 in cornfields (6.6 in 1907-1909), 31.9 in sweet clover, 24.2 in small grain stubble, 11.4 in oat fields (5.0 in 1907-1909), 6.0 in ungrazed grassland, 5.5 in fallow fields, 4.1 in pastures (5.4 in 1907-1909), and 3.4 in mixed hay (0.8 in 1907-1909). In the northern zone in 1957-1958, sand prairie had 130.5 larks per 100 acres.

No Illinois species increased more dramatically between 1909 and 1957 than the horned lark. Besides the population increase, there was an apparent change in the habitat of the lark between the two census periods; this habitat change had great bearing on the population increase. The change was probably in progress even in 1907-1909, when the lark was much more of a grassland species than in the later census years. While the statewide population increased enormously, densities in pastureland actually decreased after 1909. From the natural grassland situation, the lark has moved in increasing numbers to cultivated habitats (corn, soybeans, and hay legumes), most of them associated with row-crop agriculture. This move was from a diminishing to an expanding habitat. Modern land management seems almost specifically designed to favor the lark. The row-crop acreage is excellent lark habitat in spring and early summer, but in midsummer, as the crops grow, this acreage loses its attractiveness to the lark. Harvesting of hay and small grain in midsummer opens up a vast new acreage, and the lark population shifts to the cut fields. In the northern zone in 1957-1958, mowed hayfields had 37.4 larks per 100 acres, a density about comparable to that in row crops in early June.

The modern practice of mowing roadsides also favors the lark.

In June, 1909, the statewide population of the horned lark was estimated to be about 842,000 birds, most of them in the northern (46 per cent) and central (38 per cent) zones. The 1907 statewide summer population was higher, but probably numbered less than 1,500,000 larks (no census in northern zone). In June, 1957, the state population of larks numbered about 5,621,000 birds and, in June, 1958, 4,477,000.

As in 1907-1909, most of the horned lark population in 1957-1958 (85-90 per cent) was in the northern and central zones, but the center of abundance had shifted southward to the central zone. The June counts did not represent strictly the breeding populace. We did not include identifiable juveniles in our population calculations, but, as horned larks nest early in spring, some well-grown juveniles were probably counted as adults. Inclusion of some juveniles in the counts was probably a source of some of the year-to-year variation noted above. Early spring (February-March) temperatures were above normal in 1957, but abnormally low in 1958. Nesting was probably delayed in 1958, and the count for that year may have included few juveniles. The entire winter and early spring of 1908-09 had above-normal temperatures, and the count for June, 1909, may have had a higher proportion of juveniles than either the 1957 or the 1958 counts.

Winter habitats for the lark were the winter counterparts of the summer habitats (corn stubble or stalks, bean stubble, small grain stubble, winter wheat) and included virtually all open-field areas. In 1906-07, corn stubble, pasture, small grain stubble, and wheat, listed in order of preference, were the most favored winter habitats; in 1956-1958, bean stubble, alfalfa, and mechanically picked corn were the preferred habitats. Modern agriculture favored the lark even in winter. The cornstalk habitat (corn picked by hand and the stalks left standing), which covered much of the winter landscape in 1907-1909, was virtually unused by the lark, while the less abundant corn stubble was a favorite winter habitat of the species. Mechanized corn picking all but

eliminated the standing cornstalk habitat, which favored many other species of birds in winter, and vastly increased a habitat that favors the lark.

Winter populations of the horned lark in the state numbered about 2,416,000 birds in 1906-07, 9,175,000 in 1956-57, and 7,634,000 in 1957-58. In all census years, the ratio between winter and summer populations for the state was 1.6 or 1.7 larks in January to 1.0 the following June. The constancy of this ratio is surprising; it may provide a clue to the reproductive increment in this species, but further study on the natural history of the horned lark is needed before we can understand the significance of the ratio. Although this ratio was constant from year to year, it was not constant from zone to zone. The winter-summer ratios for the different zones imply that horned lark populations in the northern part of the state shifted southward in winter. In 1956-57, for example, the northern zone had only 0.6 lark in January to 1.0 in June and the central zone had 1.3 larks in winter to 1.0 in summer; the southern zone had 6.5 larks in winter to 1.0 in summer.

At the time of the recent survey, the future outlook for the horned lark in Illinois appeared to be entirely favorable.

Barn Swallow.—Of the six species of swallows (tree, bank, rough-winged, barn, and cliff, and the purple martin) encountered in the summer surveys, the barn swallow was undoubtedly the commonest member of its family. At the time of the early series of censuses, this bird was most abundant in the northern zone and least abundant in the southern. In the 50 years that followed, this species increased in numbers, particularly in the southern zone. In 1957-1958, the barn swallow was most abundant in the southern zone, least abundant in the northern. Population densities of the barn swallow over alfalfa fields in 1957-1958 were 4.4 birds per 100 acres in the northern zone, 24.0 in the central zone, and 38.8 in the southern zone.

The barn swallow was seen foraging in summer in a great variety of open-field habitats; it favored edge shrubs, alfalfa, sweet clover, pastures, and ungrazed grasslands. Population densities for various foraging habitats of the state in 1957-

1958 were 26.3 swallows per 100 acres over edge shrubs, 13.1 in alfalfa, 11.8 in sweet clover, 9.6 in pastures (1.7 in 1907-1909), 7.5 in ungrazed grasslands (27.0 in 1907-1909), 4.2 in red clover (5.2 in 1907-1909), 4.2 in mixed hay (3.3 in 1907-1909), 3.5 in oats and wheat (0.5 in 1907-1909), 3.4 in fallow fields (6.2 in 1907-1909), and 1.7 in corn and soybeans (0.2 in 1907-1909). Ungrazed grassland, fallow fields, and red clover, the favored habitats in 1907-1909, apparently lost some birds to alfalfa, a crop that increased greatly after 1909. Edge habitats, such as roadsides and drainage ditches, appeared to have high numbers of foraging barn swallows. Cutting enhanced fields of wheat and hay as foraging areas for swallows.

State population estimates for this species were 300,000 birds in June, 1909, and 910,000 in June, 1957. The 1907 population was probably even lower than 300,000 (no northern zone census in 1907), and the 1958 population was probably over 1,000,000. The barn swallow is another of the species that increased greatly between the early and later surveys.

Not only did population densities of the barn swallow in some favored foraging habitats (notably pastureland) increase between the two census periods; certain habitat changes favored the barn swallow. Alfalfa, one of the best habitats, became a dominant hay crop in Illinois, and other hay crops proved to be good foraging habitats for the barn swallow.

Barns, important nesting sites for the barn swallow, were probably less plentiful in 1957-1958 than in 1907-1909, but cement culverts and bridges were more numerous. The barn swallow may recently have made increased use of culverts and bridges for nesting sites.

The increasing use of potent insecticides may ultimately create problems in food acquisition for the barn swallow and other insectivorous birds, but land management practices in Illinois in 1958 appeared to favor the barn swallow and some other species of swallows.

Blue Jay.—The blue jay was recorded throughout the state, both summer and winter, in all census years.

In summer, the jay occurred in a variety of woody and open-field habitats and

showed some interesting regional variations in habitat preference. For example, in cornfields, a marginal foraging habitat, the jay was notably more numerous in all census years in northern Illinois than in the central or southern zones. In forests, population densities of the jay were highest in the central zone, lowest in the southern; in urban residential areas, jay populations were most dense in the southern zone. In some other habitats, pastureland, for example, there was little variation in the jay population from one zone to another.

In most summer habitats for which comparative figures are available, blue jay population densities were higher in 1907-1909 than in 1957-1958. In 1907-1909, the most favored blue jay habitats were forests, orchards, and residential areas. In 1957-1958, the species was numerous in residential areas and in hedgerows and edge-shrub habitat (neither of the last two habitats was censused in 1907-1909). Summer population levels of the blue jay in various habitats of the state in 1957-1958 were 67.6 birds per 100 acres in hedgerows, 30.0 in edge shrubs, 17.7 in residential areas (11.9 in 1907-1909), 8.0 in savanna-type areas, 6.6 in forest (33.3 in 1907-1909), 4.1 in orchards (20.7 in 1907-1909), 3.2 in shrub areas (16.1 in 1907-1909), 1.4 in pastureland (2.5 in 1907-1909), 0.4 in fallow fields (2.5 in 1907-1909), and 0.3 in cornfields (1.1 in 1907-1909).

The state blue jay population declined greatly between 1909 and 1957. Our estimates of the state population were 1,300,000 in 1907 (estimate based on central and southern zone populations), 1,557,000 in 1909, 460,000 in 1957, and 470,000 in 1958. The loss was apparent in all zones, but it was particularly great in the southern zone (81 per cent decline in southern zone, 47 per cent decline in northern and central zones).

The population decline in this species is surprising. The blue jay is a versatile species, nesting as it does in a variety of woody habitats. Forest, a favored habitat in 1907-1909, increased in acreage, but jay populations in forest had become relatively sparse by 1957. In orchards, a diminished habitat, recent jay populations were thinner than those of 1907-1909.

The ecology of the blue jay appears to be changing. Of all its summer habitats, only residential areas appeared to have higher populations in the recent census years than in 1907-1909. In northern Illinois in 1907-1909, the bulk of the jay population was in forest, but, in 1957-1958, most of the population was in residential areas. The causes for this change are not apparent. Gross habitat changes since 1909 appear to have been beneficial, not harmful. The fact that the jay population thinned in favorite habitats suggests such possible causative factors as competition, reduced availability of food, or disease (in essence, reduced productivity or increased mortality). We can only suggest that further study of this species is needed.

Some blue jay populations are migratory. The jays that winter in Illinois could represent breeding populations from states to the north, resident Illinois populations, or a combination of the two population groups. In 1906-07, the winter population of jays was estimated to number 833,000 birds (compared to 1,300,000 the following June); about 81 per cent of the state winter population was in the southern zone. In 1956-57 and 1957-58, the state winter populations (461,000 in 1956-57, 570,000 in 1957-58) were slightly higher than breeding populations in the following summers, but, like the summer populations, still far below the levels of the early census years. To determine precisely what happens in these population shifts and changes, there is need for an intensive blue jay banding program.

The principal winter habitats of the blue jay in all census years were shrub, forest, and orchard. Jays made relatively little use of open-field winter habitats in the recent census years, although in 1906-07 they had frequented (in sparse numbers) cornstalk habitat and pastureland. Gross changes in winter habitats do not appear to have been responsible for reducing the jay population.

Common Crow.—In summer and winter (all census years), the common crow was counted within the census strips in all zones of the state and in virtually every habitat. Crow distribution in the three zones was quite uniform, reflecting total acreage distribution; largest numbers

of crows were in the southern zone, smallest in the northern, both summer and winter.

Hedgerows, orchards, and forests were the habitats with the highest population densities of crows. Populations in most habitats were higher in 1907-1909 than in 1957-1958. Densities of crow populations in various summer habitats of the state in 1957-1958 were 15.0 birds per 100 acres in hedgerows, 5.4 in forest (6.4 in 1907-1909), 3.6 in sweet clover, 2.7 in plowed fields, 2.1 in ungrazed grassland and marshland, 2.0 in edge shrubs, 1.9 in shrub-grown areas (4.7 in 1907-1909), 0.5 in pastures (2.2 in 1907-1909), and 0.5 in cornfields (1.7 in 1907-1909). In addition, in 1907-1909, crows were found in orchards (13.5 per 100 acres), cut and shocked wheat fields (8.9 per 100 acres, in contrast to 0.2 in standing wheat), red clover (2.5), fallow fields (1.8), oat fields (1.7), and mixed hay (1.2).

Like the blue jay, the crow should presumably have benefited from gross habitat changes in the half century between census periods but, like the jay, the crow apparently declined in numbers. In June, 1909, the state crow population, according to our estimate, numbered about 1,227,000 birds. In June of 1957 and 1958, state crow populations were, respectively, 342,000 and 290,000 birds. There was no northern zone census in 1907, but crow populations in both 1907 and 1909 were well above the 1957-1958 levels.

Gross habitat changes, except possibly those that reduced food resources, probably were not the primary causes of the decline. In terms of percentage, the decline was about the same in the two corvids, the blue jay and the crow. Both species showed declines in population density in favorite habitats.

In winter, crows were distributed throughout the state in all census years, but the central zone had by far the largest part of the state population. In all census years, also, the state crow population in winter was at least two to four times as large as that in the following summer. Estimates of the state January populations were 4,805,000 in 1907 and 1,387,000 in 1957. In February, 1958, the crow population numbered about 443,000, a figure implying that dispersal of the

winter population was well along at that time of year.

Much of the difference between the winter populations and the summer populations must represent immigration of crows from breeding grounds north of Illinois.

Cornstalks, corn stubble, small grain stubble, pasture, and forest were found to be important winter habitats for the crow.

Like the summer data, the winter population figures show that crow numbers decreased between the two census periods. Furthermore, in terms of percentage change, the winter population decline matched the summer population decline almost exactly: summer, 72 per cent decline; winter, 71 per cent. Because some of the winter crow population in Illinois comes from other breeding grounds, these data imply that the decline in crow numbers occurred over a broad geographic area.

Gross changes in winter habitats between 1909 and 1956, which should have favored the crow, offer no explanation for this decline. There was more woody cover in 1956-1958 than in 1906-1909, and food was probably more abundant in recent years as use of mechanical harvesting techniques increased. The causes of the decline, whatever they were, may have been the same as those that caused a decline in the blue jay.

Chickadees.—Both species of chickadee, the black-capped and the Carolina, were recorded in summer and winter within the census strips, but nonsinging chickadees are so difficult to identify to species that we have had to combine data for the two species. Chickadees in the northern zone were undoubtedly black-caps. The Carolina was probably the common breeding species in the southern zone. Both species occurred in the central zone, and, in winter, both may have occurred in the southern zone.

In summer, chickadees were virtually restricted to habitats with some woody cover (forest, orchard, shrubs, and, to a much lesser extent, pasture). Because forest census samples were small in 1907-1909 (though probably adequate in the southern zone), we shall place emphasis on the recent population data. Population densities, especially those for the black-cap

in the northern zone, were remarkably similar in 1957 and 1958. In forest, the principal habitat, chickadee summer populations in 1957-1958 were 15.8 birds per 100 acres in the northern zone (black-cap), 10.3 in the central zone (both species), and 11.3 in the southern zone (Carolina). In shrub areas, summer densities were 6.2 chickadees per 100 acres in the northern zone, 8.2 in the central, and 8.7 in the southern. In edge shrub, summer densities were 16.7 per 100 acres in the northern zone and 30.0 in the southern. The data suggest that the Carolina chickadee may make greater use of shrub habitats than does the black-cap. Neither species of chickadee was reported in residential areas to a significant extent in either census period.

The available data suggest that the Carolina chickadee was more numerous in 1957-1958 than in 1907-1909. In the southern zone, the summer population of the Carolina chickadee did not number more than about 78,000 birds in 1907-1909, according to our estimate; chickadee populations of the southern zone numbered about 400,000 birds in 1957 and 300,000 in 1958. Even if the forest segment of the chickadee population for 1957-1958 were disregarded, the recent populations would exceed those of the early census years. Because the forest census sample for northern and central Illinois was small in 1907-1909, and because the black-cap is definitely a forest species, we cannot speculate on population trends in this species.

It is worthwhile to consider the 1957-1958 data on chickadee populations in more detail. Chickadee distribution tended to follow the distribution of woody habitats (greatest number of chickadees in the southern zone, smallest number in the northern). Far more summer habitat was available to the Carolina (in the southern zone) than to the black-cap (in the northern). The "unbalanced" habitat distribution may in part account for the higher black-cap population densities in the northern zone. We estimated that in summer the state population of chickadees (both species) numbered about 600,000 in 1957 and 460,000 in 1958. The northern zone had only about 82,000 chickadees (black-cap) in each year, while the south-

ern zone had about 400,000 (Carolina) in 1957 and 300,000 in 1958. The central zone had about 120,000 birds (both species) in 1957 and 80,000 in 1958.

In winter (all census years) chickadees invaded a large number of habitats, including fallow fields, corn stubble, hayfields, and even bean stubble and plowed fields, but, as in summer, woody types comprised the principal habitats.

Chickadees (at least the black-cap) appeared to be somewhat migratory. From the summer population levels in 1957, the 1957-58 winter chickadee populations declined in the northern zone, remained about the same in the central zone, and doubled in the southern. Migration is implied in these data; in a nonmigratory species, we should expect that in each zone the winter population would be greater than the previous summer population.

The census data indicate that there was some change in numbers of the black-cap, or in distribution of the black-cap, between 1907 and 1956. In both 1906-07 and 1956-57, the state winter population of the chickadees (both species) numbered about 1,000,000 birds, but chickadee distribution was very different in the two years. January populations for the northern zone were 230,000 in 1906-07 and 63,000 in 1956-57; for the central zone, 226,000 in 1906-07 and 105,000 in 1956-57; and, for the southern zone, 660,000 in 1906-07 and 830,000 in 1956-57. In January, most of the chickadees in the northern and central zones must have been black-caps, and their numbers were about three times as great in 1906-07 as in the recent census winters. Without better summer data, we cannot say that this apparent decline represents a real change in total numbers of the black-cap; the difference between the 1906-07 and 1956-57 populations may represent a change in winter distribution of the black-cap, or merely "natural" annual variation. Additional information is needed on the distribution of both species of chickadees, particularly on their migrations.

Tufted Titmouse.—The tufted titmouse, like the chickadees, is primarily a forest species. It is virtually restricted to habitats with some woody cover. We have meager summer data on this species for 1907-1909, except for the population of

the southern zone. In recent censuses, the tufted titmouse was found in all three zones of the state, but populations were very low in the northern zone. For example, summer population densities (1957-1958) in forests were about 20 titmice per 100 acres in the southern and central zones and only 0.6 per 100 acres in the northern zone. Southern zone populations of the titmouse in various summer habitats in 1957-1958 were 19.3 birds per 100 acres in forest (14.2 in 1907-1909), 9.4 in shrub-grown areas (5.3 in 1907-1909), 5.1 in edge shrub and residential areas, and 1.3 in orchards (13.3 in 1907-1909). A density of about 20 titmice per 100 acres may represent a kind of saturation level for central and southern Illinois forests. The recent thinning of populations in orchards (despite increases in other habitats) is a pattern observable in other species, as well as the titmouse.

The tufted titmouse increased in numbers between 1909 and 1957, at least in the southern zone, where the June population was about 324,000 birds in 1907-1909 and 550,000 in 1957-1958. There is no reason to doubt that the population increased northward, also. In 1957-1958, there were about 200,000 titmice in the central zone and about 20,000 in the northern. Our estimates for the entire state were 752,000 titmice in 1957 and 756,000 in 1958. If these figures are representative, they indicate that the titmouse population is one of the least variable for which we have data.

The increase in forest acreage has surely been beneficial to the titmouse, but the fact that forest populations of this species increased in density shows that other factors than habitat change entered into the population increase. Both the titmouse and the Carolina chickadee are cavity nesters. Because of their small size, they probably have little competition from the larger forest species, but they may compete with one another. The northward advance of the titmouse may have had some effect on the black-capped chickadee. The occurrence of the titmouse (but not the chickadees) in the urban residential areas censused is of ecological interest; at present this habitat accounts for only a very small fraction of the titmouse population of the state.

Winter distribution of the tufted titmouse through the state, the surveys showed, was similar to the summer distribution. In winter, the titmouse held to the woody habitats more than did the chickadees. The tufted titmouse is not known to be migratory; yet, in both of the recent census years, the state winter population was below the following summer population. We estimated that the state population of the titmouse numbered about 670,000 birds in January, 1957 (750,000 the following June), and 470,000 in February, 1958 (760,000 the following June). Such a pattern of seasonal fluctuation suggests the possibility of migration. There are few other data to corroborate such a view, and we should consider other possibilities. The titmouse probably begins nesting in April, and the February census figure may represent the adult breeding population better than the June figure. By June, many juveniles may be flying; the juvenile plumage in this species is similar to the adult plumage, and the June count may include many immatures.

Mockingbird.—In summer of all census years, the mockingbird was encountered in central and southern Illinois, but, in winter, this species was seen within the census strips only in the southern zone. The central Illinois population was almost negligible in the early census years; in 1957–1958, population densities of the mocker in central Illinois were only about one-third of the southern Illinois densities.

Principal summer habitats for the mockingbird were residential areas and orchards in 1907–1909 and edge shrubs (not censused in 1907–1909) in 1957–1958. Densities of mockingbird populations in various habitats of southern Illinois in 1957–1958 were 40.5 birds per 100 acres in edge shrubs, 2.6 in orchards (17.7 in 1907–1909), 1.0 in residential habitat (24.2 in 1907–1909), 0.8 in pastures (2.7 in 1907–1909), 0.8 in shrub-grown areas (2.7 in 1907–1909), and 0.4 in cornfields (2.5 in 1907–1909). In addition, in 1907–1909, fallow fields had 4.1 mockers per 100 acres, and plowed fields had 2.2 per 100 acres.

The density data indicate a decline in the state mockingbird populations between 1909 and 1957. Our estimates of summer

populations in the southern zone were 184,000 in 1907, 386,000 in 1909, 89,000 in 1957, and 54,000 in 1958 (the 1907–1909 figures do not include edge shrub, but the 1957–1958 figures do). While mockingbird numbers for the state and for the southern zone diminished between 1909 and 1957, the numbers for the central zone increased notably. In the summers of 1907–1909, there were probably fewer than 5,000 mockers in the central zone, but northward extension brought the number in this zone to about 31,000 birds in 1957. The number was down in 1958 (perhaps as low as 15,000), but it still far exceeded the 1907–1909 level. Even with the geographically extended population, the total number of mockingbirds in the state in 1957 (120,000) was below the 1907 figure (more than 184,000). The combination of geographic extension and thinning population can be observed in a few other species, for example the turkey vulture. Why the mockingbird population thinned in the southern zone we cannot say. Except for orchards and pastureland, mockingbird habitats should have been nearly as extensive in 1957–1958 as in 1907–1909. The species now seems overly dependent on one type of habitat, edge shrubs, a habitat that is being eliminated by modern farming practices. A hopeful development is the increase in recent years of multiflora rose hedges, which are much favored by the mockingbird.

By winter each year, the mockingbird population has shifted southward in Illinois, and, though a few birds may winter in the central zone of the state, the species was recorded within winter census strips in 1906–07, 1956–57, and 1957–58 only in the southern zone, in habitats that were the winter counterparts of the summer habitats. The mockingbird populations in Illinois numbered about 63,000 birds in January, 1907, and 39,000 in January, 1957. The population level in February, 1958, was much higher (187,000), probably because spring migration was under way and migrants were concentrated in the latitudes of southern Illinois.

Catbird.—In all census years, the catbird was found throughout the state in summer. It occurred in a variety of habitats (urban areas, forest, orchards, shrubs,

pastures, oats, wheat, corn, hayfields, and marsh), but in greatest densities in woody types. Population densities varied greatly from zone to zone and in no consistent pattern.

In the summers of 1957–1958, densities in forest were 2.2 catbirds per 100 acres in the northern, 7.5 in the central, and 0.3 in the southern zone; densities in residential areas were 0.6 in the northern, 4.0 in the central, and 22.4 in the southern zone. Catbird populations in various woody habitats in southern Illinois (the zone for which we have the best data for both census periods) were, for 1957–1958, 22.4 birds per 100 acres in residential areas (12.1 for 1907–1909), 5.1 in edge shrubs (14.3 for 1907–1909), 2.6 in orchards (26.5 for 1907–1909), and 0.8 in shrub-grown areas (2.0 for 1907–1909). In northern and central Illinois, the catbird (like the brown thrasher, but unlike the mockingbird) greatly favored hedgerows (1957–1958 population density: 152.7 catbirds per 100 acres). In northern Illinois, wheat fields were a favorite foraging habitat.

We estimated that the statewide summer population of catbirds numbered about 196,000 in 1957 and 220,000 in 1958. We lack data on the prime woody habitats in northern and central Illinois for 1907–1909, but, even without the catbirds in these habitats, the state population in 1909 numbered at least 278,000 catbirds. The 1907 population was lower (no northern zone census in 1907), but probably it was close to 200,000. If we make allowance for the uncensused woody habitats, we conclude that the catbird population in the state declined considerably between 1909 and 1957.

Brown Thrasher.—Of the three mimids (mockingbird, catbird, brown thrasher) in Illinois, the brown thrasher was by far the most abundant in all census years. The thrasher occurred in summer in all zones of the state, but, in 1907–1909, most of the state population was in the southern (especially) and central zones.

The brown thrasher was counted in all summer habitats except soybean fields, but this species particularly favored hedgerows and edge shrubs. Population densities varied from zone to zone and in fa-

vorite habitats tended to be highest (all census years) in the central and southern zones. In 1957–1958, thrasher populations in hedgerows were 62.9 birds per 100 acres in the northern, 188.7 in the central, and 137.0 in the southern zone; in edge shrubs, 60.9 in the northern, 68.5 in the central, and 75.9 in the southern zone; in shrub areas, 27.8 in the northern, 12.2 in the central, and 2.4 in the southern zone. In other habitats, densities tended to be more nearly uniform from one zone to another.

Densities of brown thrasher populations in various summer habitats of the state for 1957–1958 were 11.6 birds per 100 acres in orchards (23.2 for 1907–1909), 3.6 in sweet clover, 3.5 in residential areas (23.8 for 1907–1909), 2.1 in forests (15.4 for 1907–1909), 1.6 in fallow fields (2.7 for 1907–1909), 1.0 in pastures (4.9 for 1907–1909), 0.4 in alfalfa, 0.3 in corn (1.6 for 1907–1909), 0.0 in red clover (8.0 for 1907–1909), 0.0 in mixed hay (2.9 for 1907–1909). Ecologically, the thrasher was the most broadly distributed of the mimids.

As the density data imply, the brown thrasher population declined greatly between 1909 and 1957; the decline in this species was more marked than in either of the other mimids. State summer populations, according to our estimates, were about 1,558,000 thrashers in 1909 (1,172,000 in 1907 in the central and southern zones), 431,000 in 1957, and 402,000 in 1958. The 1907–1909 estimates do not include birds in the high-density edge-shrub and hedge habitats; so the difference between populations in the two periods was even more marked than our figures show.

Habitat changes, such as the reduction in orchard acreage and the elimination of many hedges, undoubtedly affected brown thrasher numbers, but such changes could account for only a small part of the total population loss. As in the other Mimidae and some of the other species studied, the thrasher's population decline, though general, was particularly marked in the southern zone of the state. To explain these changes, we need to know more about the basic biology of each species. Perhaps we are seeing the mimid population and the population of some other species in a pe-

riodic low; in the future, the numbers may increase or they may continue to decline. Whatever the trend, the need for future measurements of the populations is certainly indicated.

Robin.—Of the three thrushes (wood thrush, robin, and bluebird) recorded as nesting in Illinois in all years of the surveys, the robin was by far the most abundant.

In summer, the robin was found throughout the state in most of the habitats censused. Residential areas were clearly the favorite robin habitat in summer, at least in recent years. Orchards, edge shrubs, and hedgerows also were high density habitats. Robin populations varied from zone to zone. In 1907–1909, population densities tended to be highest in the southern zone of the state, lowest in the northern zone. In 1957–1958, densities tended to increase with north latitude. Residential areas in 1907–1909 had 27.8 robins per 100 acres in the northern, 33.5 in the central, and 36.3 in the southern zone, while, in 1957–1958, these areas had 132.2 in the northern, 108.6 in the central, and 101.9 in the southern zone.

In forest, the 1907–1909 summer densities were 6.4 robins per 100 acres in the central and 15.0 in the southern zone; the 1957–1958 summer densities were 6.1 in the central and 0.3 in the southern zone. Robin numbers apparently increased greatly in residential areas between 1909 and 1957, but, in many other habitats, the numbers were greater in the early than in the later census years. Summer densities in various habitats of the state for 1957–1958 were 60.0 robins per 100 acres in hedgerows, 24.6 in edge shrubs, 6.6 in orchards (34.9 for 1907–1909), 5.1 in ungrazed grassland in the northern and central zones (6.8 for 1907–1909), 1.9 in pastureland (7.3 for 1907–1909), 1.9 in shrub-grown areas (3.1 for 1907–1909), 1.8 in mixed hay (1.8 for 1907–1909), 1.4 in red clover (4.3 for 1907–1909), 0.9 in corn (1.6 for 1907–1909), and 0.7 in oats (0.5 for 1907–1909).

Population densities of the robin in most summer habitats decreased between 1909 and 1957. We estimated that the state population in June numbered about 1,900,000 robins in 1909 (in 1907 probably about 1,400,000), 1,500,000 in 1957,

and 1,360,000 in 1958. The geographic and ecological distribution of the robin seems to have changed. In the summers of 1907 and 1909, the robin population was fairly uniformly distributed throughout the state. Forest and pastureland accounted for the bulk of the 1907–1909 summer population, but the robin was well represented in a variety of other habitats. It was an ecologically broad species. In 1957–1958, most (65 per cent) of the Illinois robins were in the northern zone. The robin was primarily (75 per cent of the state population) an inhabitant of man's communities (urban residential areas and farmyards). Reduction of pastureland probably hurt the robin, but residential areas provided the essential requirements (tree nesting sites and clipped grass foraging areas) of the pasture habitat and perhaps improved on this habitat. One possible disadvantage of this specialization in habitat is that the use of chemicals (insecticides and herbicides) toxic to robins is especially prevalent in urban areas. Except for the possible danger from these chemicals, the future for the robin seems bright. In the coming decades, urban areas are sure to increase.

In winter, a few robins may be found even in the northern zone of the state, but, within the census transects, this species was found in only the southern zone in the winter of 1906–07 and in only the southern and central zones in the winters of 1956–1958. The primary winter habitats of the robin were picked (cornstalk) cornfields, forest, and orchards in 1906–07 and shrub areas, forest, and pastures in 1956–1958.

The robin may have wintered farther north in greater numbers in recent years than at the time of the early survey. In 1906–07, a notably mild winter, the Illinois robin population in January (none recorded in any zone but the southern) was probably less than 100,000 birds. The number of robins in the state in January, 1957, was estimated to be 1,366,000 (all but 15,000 in the southern zone). This population was about the same as the June, 1958, population for the state. In February, 1958, the number of robins was down to 664,000 (none recorded in the central or northern zones). Because the February population showed no north-

ward shift, we presume that many wintering robins drifted southward in late winter before the onset of spring migration. This pattern of movement was similar to that in a number of other species.

Eastern Bluebird.—In both survey periods, the eastern bluebird was found throughout the state in summer and winter; population densities in summer tended to be highest in the southern zone and lowest in the central. In most years the southern zone had the bulk of the state population, but in 1958 the bluebird suddenly all but disappeared from southern Illinois.

Favorite summer habitats of the bluebird were edge shrubs, forest, pastures, and fallow fields, but the bluebird was found also in cornfields, plowed fields, oats, mixed hay, red clover, and marsh. Densities of bluebird populations in various habitats in the southern zone for 1957 were 8.3 birds per 100 acres in pastures (2.8 for 1907–1909), 2.6 in fallow fields (3.7 for 1907–1909), 1.7 in forest (6.7 for 1907–1909), 1.5 in shrub-grown areas (1.8 for 1907–1909), and 0.0 in corn (1.7 for 1907–1909). Roadside habitats are well-known favorites of the bluebird, and in 1957, along roads in southern Illinois, shrub areas had 33.6 bluebirds per 100 acres and ungrazed grass areas had 10.3 per 100 acres. Most density figures were higher in the early than in the recent surveys. A notable exception to the trend was the recent high-density figure for pastureland. The great loss in pastureland acreage between 1909 and 1957 could have had some concentrating effect on the bluebird population.

In June, 1909, the number of bluebirds in Illinois was estimated to be 460,000 (70 per cent in the southern zone); the population was higher in 1907 (no northern zone census), possibly as high as 600,000. In June, 1957, the state had about 220,000 bluebirds (80 per cent in the southern zone); by the following summer the population had fallen to an almost unbelievable low of about 50,000 birds. Strangely, the northern zone population was still intact, but the central zone population was badly decimated and the southern zone population was virtually gone. We would have been inclined to doubt our census data, except that at about the

same time sharp declines were noted widely by field observers in the eastern United States (James 1962:308). As of October, 1962, the Illinois bluebird population had shown only slight recovery.

In winter (all census years), the southern zone had virtually all of the bluebirds in Illinois. The birds were encountered usually in small flocks and in a variety of winter habitats. In all census years, they frequented forests, shrub areas, ungrazed grasslands, and pasture; in recent census years, alfalfa fields. The winter populations of the bluebird in Illinois were remarkably similar in the census years, numbering about 680,000 in January, 1907 and 1957, and about 720,000 in February, 1958. The number of bluebirds wintering in the northern and central zones (combined) did not exceed 25,000 birds in any census year; in February, 1958, we found no bluebirds outside the southern zone. In comparison with populations of other years, the winter population of 1957–58 in the southern zone appeared to be about normal as late as mid-February; yet the breeding populations of the southern zone and most of the central zone never appeared. What happened to these populations remains a mystery. Diminished food resources in some areas, coupled with the enduring severe cold of January–March, 1958, would certainly have taken a toll; a number of authors have discussed weather that was harmful to the bluebird (Musselman 1941:409–10; Hancock 1888:433; and others). James (1962:310), in discussing the decline of the bluebird population in relation to weather, suggested that something other than severe weather alone was responsible for the decline.

There is evidence other than the Illinois census data that the decline in bluebird numbers has been in progress for a long time. Writing about 50 years ago, Barnes (1912:328) felt that the bluebird as a nesting bird was not one-tenth as common as 20 years before and, a few years later, Ridgway (1915:196) noted that the bluebird had been “mainly displaced” by another cavity nester, the house sparrow.

Starling.—Shortly after being introduced successfully into the United States (New York) in 1890, the starling began

to extend its range westward. The species had not reached Illinois at the time of the first survey (1906-1909); it was evidently rare in this state in 1926 (Eifrig 1927:432). Today, it is one of the most abundant species in Illinois. Both in summer and winter of 1956-1958, starlings were seen throughout the state in virtually every habitat.

In summer, we found, no other Illinois habitat was as important to the starling as urban areas, and, to a large extent, the distribution of this habitat influenced the distribution of the breeding populations of the starling in the state. Our data on population densities of the starling in different habitats suggest that there was some notable regional variation in the ecology of this bird. In the southern zone, for instance, the starling was even more decidedly an urban resident than in the northern and central zones. Urban area densities were about 120 starlings per 100 acres in the northern and central zones and 180 per 100 acres in the southern. In rural habitats, starlings in the southern zone had notable populations in orchards (30.9 per 100 acres, in contrast to 13.6 in the central zone), edge shrubs (high populations in all zones), and corn (8.5 per 100 acres, in contrast to 0.2 in the central zone). For central zone starlings, hayfields were consistently the favored rural habitats. Starling densities in various types of hay were as follows for the central zone: 117.1 birds per 100 acres in mowed hay (44.0 for the northern, 0.0 for the southern), 97.9 in red clover (10.9 for the northern, 0.0 for the southern), 48.0 in alfalfa (4.4 for the northern, 0.0 for the southern), and 3.6 in mixed hay (0.7 for the northern, 1.7 for the southern). For starlings in the northern zone, the principal rural habitat was pastureland; densities were 17.5 starlings per 100 acres in the northern zone, 2.9 in the central, and 3.3 in the southern. Regional variations in starling ecology may be based on the timing of the breeding season (at different stages in the breeding cycle, starlings may forage in different areas). The subject deserves detailed study.

Starling populations, even in summer, were extremely variable from place to place and from year to year. This variability reflected the extreme gregariousness

(especially great in winter) of the species. Our population estimates for the starling are therefore particularly rough. In Illinois, starlings begin nesting in March and April, and by June they have some young on the wing. As the juvenile plumage is distinctive and fairly long-retained, we could segregate juveniles from adults. Our estimate of the state breeding population, 3,100,000 birds, did not include farmyard habitat, a habitat that may total nearly 200,000 acres and probably harbors a large number of starlings.

In winter, the starling was found throughout the state, but, like many other species, it was most abundant in the southern zone. In all zones, the most consistently favored winter habitat of those censused was small grain stubble. Fallow fields and shrubbery (all types) were also high density habitats in winter. We estimated that the state population of starlings in January, 1957, may have exceeded 11,000,000 birds, over 90 per cent of them in the southern zone. We have inadequate winter data on urban areas, and, considering the extreme gregariousness of the starling in winter, we believe this estimate may be very unreliable; however, there can be no doubt that the starling is near the top of the state list of birds in terms of abundance.

Yellowthroat.—Of the 22 species of warblers encountered in the course of the surveys (all years), the yellowthroat was the most widespread, ecologically as well as geographically. The yellowthroat was found throughout Illinois in summer, but most of the state population was in the southern zone; densities tended to thin northward. Many of the warblers are primarily forest species, but the yellowthroat frequents a variety of open-field habitats.

Edge shrubs, probably the most consistently favored yellowthroat habitat, had summer population densities of 24.7 birds per 100 acres in the northern, 106.6 in the central, and 120.0 in the southern zone in 1957-1958. Southern zone population densities of the yellowthroat in various other habitats in 1957-1958 were 139.0 birds per 100 acres along drainage ditches, 91.3 in hedgerows, 84.9 in marshes (9.3 in 1907-1909), 10.9 in shrub-grown areas (26.4 in 1907-1909), 5.9 in red clover,

3.9 in orchards (6.6 in 1907-1909), 3.9 in fallow fields (2.5 in 1907-1909), 2.5 in forest (11.7 in 1907-1909), 1.7 in mixed hay (2.1 in 1907-1909), and 0.7 in wheat fields (1.0 in 1907-1909). In 1907-1909, pastures and oat fields had about 1 yellowthroat per 100 acres.

The state population of the yellowthroat appeared to change little between 1909 and 1957, either in number or distribution. We estimated that state (summer) populations were about 414,000 birds in 1909 (90 per cent in the southern zone), 362,000 in 1957, and 427,000 in 1958 (80 per cent in the southern zone, both recent census years).

House Sparrow.—First successfully introduced into the United States in New York in 1852, the house sparrow was later introduced into other states. At least four introductions were made in Illinois in the period 1868-1876 (Barrows 1889:19). By 1886, virtually the entire state of Illinois, as well as a large part of the rest of the United States, was occupied by this species. The urban areas of the country were ideal for the introduced species, and the house sparrow spread through this habitat very rapidly.

In all census summers, the densities of house sparrow populations in urban and rural Illinois were highest in the central and northern zones, lowest in the southern. In rural cropland habitats, densities were conspicuously high (all census years) in the central zone, but in urban residential areas in recent census years the northern zone had the highest populations in the state. For example, 1957-1958 populations in red clover fields were 10.9 sparrows per 100 acres in the northern zone, 51.2 in the central, and 1.2 in the southern, but, in urban residential areas, the densities were 434.8 in the northern zone, 378.3 in the central, and 271.0 in the southern.

Residential areas are probably the most important habitat for the house sparrow, but few Illinois species have a more cosmopolitan distribution. Only from forests is this sparrow largely absent. Population densities of the house sparrow in important summer habitats in the state in 1957-1958 were 373.7 birds per 100 acres in residential areas (265.2 in 1907-1909), 195.2 in edge shrubs, 56.4 in un-

grazed (largely roadside) grassland, 46.1 in orchards (125.5 in 1907-1909), 31.8 in pastures (21.5 in 1907-1909), 22.0 in oats (9.7 in 1907-1909), 20.7 in red clover (11.7 in 1907-1909), 13.1 in alfalfa, 12.3 in mixed hay (16.7 in 1907-1909), 4.8 in corn (4.6 in 1907-1909), 4.2 in soybeans, 3.4 in fallow fields (32.2 in 1907-1909), 3.2 in wheat (29.5 in 1907-1909), and 0.1 in forest (2.2 in 1907-1909).

In most summer habitats, population densities of the house sparrow in recent census years were higher than those in 1907-1909. Notable exceptions were orchard, fallow fields, and wheat. House sparrow populations in most habitats declined in the southern and increased in the northern zones, and both the density increase of house sparrow populations in oats (a northern zone crop) and the decrease in wheat (a southern zone crop) were probably related to a general northward shift in the population. Despite population increases of the house sparrow in certain habitats, the statewide populations of 1957-1958 were not much greater than that of 1909. We estimated that the state June populations of house sparrows numbered about 5,300,000 birds in 1909 (probably about the same in 1907), 6,150,000 in 1957, and 5,500,000 in 1958. The number of immatures in these populations is unknown. Urban populations of house sparrows were much greater in 1957-1958 than in 1907-1909, but rural populations, particularly in the southern zone, probably were lower; so the net change for the whole state was not great.

Rand (1956:69-70) and others pointed out the probable importance of domestic livestock in the ecology of the house sparrow and suggested that house sparrow populations in cities declined in recent decades because of the disappearance of horses from the streets. Rand also noted that sparrow populations were more dense in suburban areas than in the business districts of a large city. Obviously, some prime sparrow habitat is being lost as residential areas near the center of the city give way to the business district, but the net change is toward great expansion of good sparrow habitat. The Illinois population of house sparrows will almost certainly increase in the coming decades.

House sparrow populations in open-field habitats (all census years) declined from an average of about 18 per 100 acres in summer to about 3 in winter. Winter brought no conspicuous increase in sparrow numbers in shrub or forest habitat; most of the sparrow population wintered in farmyards and urban areas. There is a parallel situation in the introduced mammal, the house mouse, which in spring expands its habitat to open fields and withdraws in fall and winter to human habitations. Because we had inadequate data for residential habitats in winter, we could not estimate the state populations of the house sparrow for this season.

Bobolink.—In the summer surveys (all years), the bobolink was encountered in both northern and central Illinois, but most of the state population was in the northern zone. Though the principal summer habitats, hayfields (all types), oats, pastures, and ungrazed grassland, were well represented in the central zone, population densities of the bobolink in this zone were consistently below those in the northern. In mixed hay, for example, there were about 60 bobolinks per 100 acres in northern Illinois, but only 11 in the central zone. Population densities of the bobolink in various summer habitats of the northern zone in 1957–1958 were 62.1 birds per 100 acres in mixed hay (53.1 in 1909), 52.9 in oats (3.7 in 1909), 44.3 in alfalfa, 38.1 in red clover (18.0 in 1909), 13.6 in pastures (5.2 in 1909), and 5.2 in ungrazed grassland (54.1 in 1909). The relatively dry margins of marshes were probably a favored habitat in 1909 (88 bobolinks per 100 acres). The apparent increased use of oat fields by the bobolink (a change that can be seen in other prairie species) helped to balance the loss in acreage of ungrazed grassland (a favored bobolink habitat in 1907–1909) and pastureland.

We estimated that the June populations of bobolinks in Illinois were 1,175,000 birds in 1909, 1,860,000 in 1957, and 1,360,000 in 1958. In the central zone, the population increased from less than 15,000 birds in 1909 to more than 100,000 in 1957–1958. The statewide increase fits a pattern of population increase and range extension that is observable in several species of open-field Icteridae.

Meadowlarks.—In all census years, meadowlarks were encountered throughout the state in both summer and winter, but, because of difficulty in determining the species of nonsinging meadowlarks, we do not know the relative proportions of the eastern and western species. Our data represent both species, at least in the northern and central zones. All meadowlarks in the southern zone in summer, as far as we could determine, were of the eastern species. Though specimens were taken in Illinois at least as early as 1876 (Allen 1880:54), the western meadowlark was not sufficiently common to be recorded in the 1907–1909 surveys. In the past 50 years the western meadowlark has greatly extended its range and is now common in both the northern and central zones of Illinois.

In most summer habitats, meadowlark populations were more dense in the southern than in the northern zone (all census years); after 1909, populations in the northern zone increased in most habitats. For example, in red clover fields, population densities were, for the northern zone, 29.0 meadowlarks per 100 acres in 1957–1958 (9.0 in 1909); for the central zone, 47.8 in 1957–1958 (17.1 in 1907–1909); and, for the southern zone, 49.7 in 1957–1958 (39.5 in 1907–1909). The fact that meadowlark populations in the northern zone increased suggests that the western meadowlark may have been the species that particularly increased in numbers. In a few habitats, meadowlark populations in the southern zone decreased between 1909 and 1957. In ungrazed grasslands or prairie, for instance, meadowlark populations in the southern zone declined from about 63 birds per 100 acres in 1907–1909 to 50 per 100 acres in 1957–1958, even though in the northern zone populations increased from about 47 birds per 100 acres in 1909 to 80 per 100 acres in 1957–1958.

Though the meadowlarks were found (all census years) in all habitats except urban, the most important meadowlark habitats were grasslands and hayfields of all kinds. Summer population densities of the meadowlarks in various habitats of the state in 1957–1958 were 58.0 birds per 100 acres in ungrazed grasslands (63.4 in 1907–1909), 48.2 in sweet clover, 44.2 in

alfalfa, 43.2 in mixed hay (44.8 in 1907-1909), 42.1 in pasture (23.5 in 1907-1909), 41.1 in red clover (30.9 in 1907-1909), 20.0 in edge shrubs, 17.9 in fallow fields (45.7 in 1907-1909), 8.0 in oats (6.3 in 1907-1909), 7.1 in marsh (10.4 in 1907-1909), 5.8 in orchards (15.4 in 1907-1909), 4.2 in wheat (9.8 in 1907-1909), 2.7 in corn (1.9 in 1907-1909), and 2.3 in soybeans.

Meadowlark population densities in the several hay crops varied considerably from summer to summer (from as low as 20 birds per 100 acres in one year to as high as 50 the next year in a given crop, such as red clover), but the total number of meadowlarks in all hay crops combined tended to remain fairly constant from summer to summer. These data suggest that in the meadowlarks there may be considerable switching of habitat from one year to the next. In some places, in hay crops of the northern zone, particularly, the density of the meadowlark population in a given crop appeared to vary inversely with density of the redwinged blackbird population. We suspect that the meadowlarks and the redwing were reacting to something in the environment other than each other, but the relationship between them needs to be studied along with their specific habitat preferences.

The state population of the meadowlarks in June, by our estimates, numbered 4,760,000 in 1909; in 1907, the population may have been as low as 3,200,000. The estimates for both 1957 and 1958 were 3,800,000. The size of the state population may not have changed greatly between census periods, but the distribution of the population changed considerably. In June, 1909, there were only about 680,000 meadowlarks in the northern zone of the state, in contrast to 1,100,000 in both 1957 and 1958. The southern zone had about 2,000,000 in 1907, 3,100,000 in 1909, 1,900,000 in 1957, and 1,600,000 in 1958. The data suggest that the northern population of meadowlarks increased and that the southern population may have declined somewhat.

By winter in all census years, the meadowlark population had shifted southward, and the bulk of the state population was in the southern zone. Favorite winter habitats of the meadowlarks were hand-

picked (cornstalk) cornfields (1906-07 only), hayfields of various types, small grain stubble, and mechanically picked cornfields (1956-1958 only).

In 1906-07 particularly, the northern and the central zones of Illinois had almost negligible wintering populations of meadowlarks (probably fewer than 10,000). In the recent census years, meadowlarks wintered farther north in larger numbers; in January, 1957, there were probably about 300,000 in the northern and central zones combined. By our estimates, the southern zone had January populations of about 3,100,000 meadowlarks in 1907 and 3,400,000 in 1957. Like a number of other species, in late winter the meadowlarks probably move farther to the south before they move north to their breeding grounds. In February, 1958, the central and northern zones probably had fewer than 10,000 meadowlarks, and the population in the southern zone was down to 1,400,000 birds, concentrated primarily in hayfields that provided good cover.

Redwinged Blackbird.—Few species have undergone a more spectacular population increase since the turn of the century than the redwinged blackbird. The redwing was common even in 1907-1909, and the species was recorded throughout the state in all census years. In summer, densities of redwing populations varied from zone to zone and in most habitats were highest in the northern zone (all census years). In 1957-1958, densities in mixed hay decreased from north to south (northern zone: 198.7 redwings per 100 acres; central: 87.4; southern: 53.1).

The redwinged blackbird was observed in a variety of summer habitats (all census years) including marshes, drainage ditches, all types of hay crops, all types of grassland, fallow fields, oats, wheat, corn, soybeans, plowed ground, shrubbery of all types, orchards, and forest; marsh, edge shrub, sweet clover, and mixed hay were notable favorites. The redwing was primarily a marsh species originally; even in 1957-1958, population densities were higher in marshland than in any other major habitat. Long before the first surveys, marshland was a disappearing habitat in Illinois, and the redwing in this state has made greater and greater use of

cultivated lands. Between 1907-1909 and 1957-1958, while marshland acreage in Illinois dwindled from about 600,000 acres to 60,000, population densities of the redwing in mixed hay increased from about 14 per 100 acres to over 130.

Summer population densities of the redwing in important habitats of the state in 1957-1958 were 300.8 in marshes (309.8 in 1907-1909), 341.7 in edge shrubs, 203.6 in sweet clover, 158.0 along drainage ditches, 134.3 in mixed hay (14.1 in 1907-1909), 88.5 in red clover (16.1 in 1907-1909), 64.5 in oat fields (3.9 in 1907-1909), 63.7 in ungrazed grasslands (47.6 in 1907-1909), 57.8 in alfalfa, 30.1 in wheat (6.5 in 1907-1909), 26.5 in fallow fields (3.3 in 1907-1909), 23.5 in pastureland (6.0 in 1907-1909), 23.0 in shrub-grown areas, 4.6 in cornfields (1.6 in 1907-1909), and 3.3 in soybeans.

In June, 1909, there were, by our estimate, about 5,100,000 redwinged blackbirds in the state; the 1907 population may have been as low as 4,000,000. In June, 1957, the state population numbered about 8,400,000 and, in June of the following year, over 11,000,000. In 1907-1909, the distribution of the state redwing population followed the distribution of marshland (high in the northern zone, low in the southern zone); marsh habitat accounted for about 60 per cent of the state population. In 1909, in the southern zone, where marshes were least abundant, the redwing population (about 700,000 birds, in contrast to 2,400,000 in the northern zone) was already largely in cultivated habitats. In 1957-1958, marshes accounted for less than 3 per cent of the state redwing population, and the species had become more uniformly distributed in the state.

The redwing is an example of a species that has adapted to a changing environment. While hayfield populations of the redwing have not attained such high densities as marsh populations, the hayfields in recent years accounted for most of the state population. Although hayfields are the most important nesting habitats, the great increase of redwings in oat and wheat fields should be noted. Small grain fields have been only marginal nesting habitats, but they are probably important foraging habitats. Redwing populations in

the state are probably still expanding, and efforts to control "blackbirds" because of their depredations on grain are expected to increase.

The redwinged blackbird was not recorded anywhere in the state in the winter survey of 1906-07. In the recent census years, the winter redwing populations in the northern and central zones of Illinois were all but negligible (fewer than 10,000 birds); in the southern zone, the species was common but it was spottily distributed. Favored winter habitats were cornfields, shrubbery of all types, and pasture. In January, 1957, we estimated, there were about 5,200,000 redwings in the southern zone. This great increase in the wintering population reflected the general increase, already noted, and probably also a tendency in the species (as noted in other species) to extend its winter range northward. The great disparity in redwing numbers between the southern zone and the central and northern zones implies that the winter range of the redwinged blackbird cannot expand much north of 39 degrees latitude without a change in climate.

Orchard Oriole.—The orchard oriole was found throughout the state in summer (all census years), but it was sighted four times as frequently in the southern as in the central zone and was least common in the northern zone. During the course of the censuses, this species was found in pastureland, fallow fields, mixed hay, red clover, wheat fields, cornfields, and forest, besides the favorite habitats: orchards, shrubbery of all types, and (in 1907-1909) residential areas. Because the 1907-1909 samples of woody habitats for the northern and central zones were particularly small, we placed emphasis on data from the southern zone in considering population changes in this species.

Densities of orchard oriole populations in various habitats in the southern zone in 1907-1909 were 42.0 birds per 100 acres in orchards (1.3 in 1957-1958), 18.1 in residential areas, 10.0 in shrub-grown areas (7.1 in 1957-1958), 3.6 in pastures (2.5 in 1957-1958), 2.8 in fallow fields (0.4 in 1957-1958), and 1.5 in mixed hay. Hedgerows and edge shrubs, for which we have no 1907-1909 data, were probably the best orchard oriole hab-

itats in 1957-1958, with densities of about 20 orioles per 100 acres in the southern zone. In 1957-1958, red clover (3.5 orioles per 100 acres) was a favored foraging habitat in the southern zone.

Orchard oriole populations were probably never very great in the northern or central zones. In those zones, by our estimate, there were at least 50,000 orchard orioles in marginal (nonwoody) habitats in June, 1909, but less than 25,000 in all habitats in 1957 and 1958. June populations of orchard orioles in the southern zone numbered about 375,000 birds in 1907, 415,000 in 1909, 97,000 in 1957, and 65,000 in 1958. Habitat changes, the great losses in orchard acreage particularly, had much to do with the decline in the oriole population, but other factors than acreage changes must have been involved in the population decline. The orchard oriole was apparently much more common in residential areas in 1907-1909 than in recent years. Also, oriole population densities in orchards declined greatly between 1909 and 1957. Some qualitative characteristics of these prime oriole habitats must have changed, and these changes, in turn, had a serious effect on the oriole population. The changing orchard oriole population is another of the ornithological problems that need further study.

Common Grackle.—During the course of the censuses (all years), the grackle was encountered commonly in summer throughout the state but only once in the winter season (southern zone). Population densities (all census years) in most habitats were highest in the northern zone, lowest in the southern. In marshes, for example, densities in both 1907-1909 and 1957-1958 were about 130 grackles per 100 acres in the northern zone but only 11 per 100 acres in the southern.

Favorite summer habitats were edge shrubs and hedgerows, marshes, and residential areas, but grackles were found in all of the habitats censused. Densities of grackle populations in various summer habitats of the state in 1957-1958 were 268.5 birds per 100 acres in edge shrubs, 225.2 in hedgerows, 158.0 in drainage ditches, 97.7 in marshes (56.8 in 1907-1909), 58.7 in residential areas (18.4 in

1907-1909), 33.7 in orchards (27.0 in 1907-1909), 25.6 in ungrazed grasslands (5.3 in 1907-1909), 19.3 in mowed hay, 17.9 in sweet clover, 16.5 in red clover (37.1 in 1907-1909), 15.2 in fallow fields (5.4 in 1907-1909), 12.8 in pastureland (13.2 in 1907-1909), 12.3 in mixed hay (6.0 in 1907-1909), 10.6 in forest (10.2 in 1907-1909), 7.4 in wheat (5.3 in 1907-1909), 6.6 in corn (7.7 in 1907-1909), 6.2 in shrub-grown areas (1.8 in 1907-1909), 5.7 in oats (7.1 in 1907-1909), 4.8 in soybeans, and 2.6 in alfalfa. In most habitats, the recent trend was toward increased population densities. The orchard populations are of interest, because the grackle is one of the very few species that had orchard populations as dense in 1957-1958 as in 1907-1909.

Despite the high population densities of the grackle in certain habitats in recent years, the state population of grackles declined slightly between 1909 and 1957, possibly because of habitat changes, particularly loss of marsh and orchard acreage. We estimated that June populations of grackles in the state were about 4,100,000 in 1909 (probably about the same in 1907), 3,600,000 in 1957, and 3,500,000 in 1958. The grackle population of Illinois changed in distribution between the two periods. In 1907-1909, grackles were concentrated especially in the northern zone (41 per cent of the state population) and the central zone (37 per cent) but, in recent census years, the central zone had only about 15 per cent of the state population. The cause of this regional change is not apparent. The increase in urban acreage should tend to swell the grackle population, particularly in northern Illinois, where the population density is highest.

Brown-Headed Cowbird.—In all census years, the brown-headed cowbird was found throughout the state in summer, but only in recent years and in the southern zone was it found in the winter season. Summer cowbird populations tended (all census years) to be most dense in the northern zone. In 1907-1909, the southern zone had the lowest population densities, but, in the recent census years, the central zone had the lowest densities.

The cowbird was encountered in virtually all of the summer habitats. Densities were highest in edge shrubs, hedgerows,

and shrub-grown areas, which are probably the principal habitats of the cowbird hosts, but the cowbird appeared to have less marked habitat preferences than most species of Illinois birds. Densities of cowbird populations in various Illinois habitats in 1957-1958 were 55.5 birds per 100 acres in edge shrubs, 30.0 in hedgerows, 17.8 in shrub-grown areas (14.2 in 1907-1909), 7.8 in forest (6.4 in 1907-1909), 7.5 in marsh, 5.4 in pastureland (8.3 in 1907-1909), 5.1 in ungrazed grassland, 2.9 in fallow fields (2.7 in 1907-1909), 2.7 in mixed hay (1.6 in 1907-1909), 2.5 in orchards, 2.1 in red clover (2.5 in 1907-1909), 1.8 in corn (1.7 in 1907-1909) and sweet clover, 1.3 in alfalfa, 0.9 in wheat (1.3 in 1907-1909), and 0.3 in oats (1.6 in 1907-1909).

Year-to-year variation in the cowbird population was particularly high, but we judge that the state population declined between 1909 and 1957. In nonwoody habitats in June, 1909, the state population numbered about 1,800,000 cowbirds. The 1907 population in nonwoody habitats was probably about half as great (estimated from populations in the central and southern zones). In the recent census years, woody habitats accounted for most of the state cowbird populations, estimated to number about 1,130,000 in 1957 and 920,000 in 1958. To some extent, the decline of pastureland acreage may have hurt the cowbird, particularly in the northern and central zones. Pastures were probably important to the cowbird, both as foraging and "nesting" habitats; northern zone densities in this habitat were about 23 cowbirds per 100 acres in 1907-1909 and only 5 in 1957-1958).

Despite the large summer populations in the early census years and the mildness of the 1906-07 winter, no wintering cowbirds were reported in the early survey. About 350,000 cowbirds (most of them in shrub areas and small grain stubble) were found in the southern zone in January, 1957, but none in February, 1958. Like a number of other species, the cowbird may be wintering farther north now than in earlier years.

Cardinal.—In the recent census years, the cardinal was recorded throughout the state, both in summer and winter. Perhaps because of the small samples of woody

habitats censused, it was not recorded in northern Illinois in 1906-1909. The cardinal has greatly extended its range northward since the turn of the century. In the later census years, the summer population thinned progressively north of the southern zone. For example, recent cardinal populations in Illinois forests in summer were about 23 birds per 100 acres in the southern zone but only 10 in the northern.

The cardinal was found during the summer surveys in marsh, fallow fields, ungrazed grassland, pastures, mixed hay and alfalfa fields, wheat, and corn, as well as in the favored woody habitats. Population densities in various habitats of the southern zone in 1957-1958 were 160.0 cardinals per 100 acres in edge shrubs, 22.8 in forest (23.4 in 1907-1909), 20.6 in orchards (13.3 in 1907-1909), 15.8 in shrub-grown areas (36.1 in 1907-1909), and 9.2 in residential areas. Small samples of hedgerow acreage in Illinois had populations averaging about 240 cardinals per 100 acres in 1957-1958.

The cardinal population in the state increased between 1909 and 1957 largely because of range extension, but also because of increased acreage of the favored woody habitats. In June, 1909, in all habitats (including woody habitats), there were about 650,000 cardinals in the southern zone; in June, 1907, there were about 400,000. In 1957 and 1958, southern zone populations were, respectively, about 780,000 and 980,000. The southern zone then had about 70 per cent of the statewide cardinal population, which numbered about 1,200,000 birds in 1957 and 1,300,000 in 1958. Only about 8 per cent (100,000 birds) of this total was in northern Illinois. We could not estimate the northern and central zone populations of cardinals for 1907-1909, because of the small samples of woody habitats censused. A forest sample in central Illinois in 1907-1909 indicated a population of about 19 cardinals per 100 acres, in contrast to 31 per 100 acres in 1957-1958. Cardinals were found in central zone pastureland in 1957-1958, but not in 1907-1909. It is clear that the northern and central zone populations of cardinals increased greatly between 1909 and 1957.

The acreage of woody habitat in the

cardinal's range increased between 1909 and 1957, but the summer population density in southern Illinois forests remained about the same. This situation suggests that the cardinal population in southern Illinois was about at the saturation point in 1907-1909 and remained so, keeping pace with the expanding habitat. Our data for central Illinois, though limited, suggest that the central zone habitats of cardinals were not saturated in 1907-1909, but that they were in 1957-1958; in the second census period, densities recorded for the central zone were even higher than those for the southern zone. The northern zone, apparently, had virtually no cardinal population in 1907-1909, and, even in 1957-1958, the habitats in the northern zone were far from saturated. In the coming decades, the cardinal population should continue to increase. Residential habitat is not so good for the cardinal as the natural types, but urbanization, as long as it encroaches on cultivated lands and not on forest, will benefit the cardinal.

Winter distribution of the cardinal followed the summer pattern (highest population in the southern zone, lowest in the northern); the surveys showed there was some tendency for the cardinal to visit open-field habitats more in winter than in summer.

The cardinal is supposedly not migratory, but our data suggest that there may be a southward shift of the population in midwinter. In January, 1957, the entire state had an estimated population of about 2,000,000 cardinals (1.6 times the June population), of which 1,700,000 were in the southern zone. The number of cardinals in northern and central Illinois in January seemed to fall below the June level; the southern zone population in January was about 2.1 times its June level, in both 1907 and 1957. This hypothesized "migration" of the cardinal presents a problem that needs investigation through banding.

Indigo Bunting.—In all census years, the indigo bunting was found throughout the state in summer. The bunting population was most dense in the southern zone and decreased progressively northward. In Illinois forests, for example, population densities were about 17 buntings per 100

acres in the southern zone, 8 in the central zone, and 4 in the northern.

In the course of the surveys, the indigo bunting was counted in virtually every habitat; woody types were the most important habitats. Densities of bunting populations in various summer habitats of the southern zone in 1957-1958 were 295.0 birds per 100 acres in edge shrubs, 234.5 along drainage ditches, 228.3 in hedgerows, 39.9 in shrub-grown areas (42.2 in 1907-1909), 17.5 in forests (28.4 in 1907-1909), 12.9 in orchards (11.0 in 1907-1909), 8.7 in wheat fields (1.7 in 1907-1909), 7.4 in fallow fields (0.9 in 1907-1909), 6.8 in ungrazed grasslands, and 4.1 in pastures (0.3 in 1907-1909). The apparent increased importance of wheat fields as foraging habitat for this species in recent years is worthy of note.

The number of indigo buntings in Illinois probably increased at least slightly between 1909 and 1957. Population densities apparently did not change greatly in any zone, but the acreage of prime woody habitats for buntings increased in the southern zone and (slightly) in the central zone, the zones with the highest bunting populations. We estimated that June populations of indigo buntings in the southern zone numbered (in all habitats but edge shrub) about 850,000 birds in both 1907 and 1909 and (in all habitats) 1,400,000 in 1957 and 1,100,000 in 1958. We could not estimate summer populations in the northern and central zones for 1907 and 1909, because of the paucity of data on woody habitats, but our information on other habitats indicates that the bunting population of the state was higher in 1957-1958 than in 1907-1909. We estimated that the entire state had about 1,700,000 indigo buntings in 1957 and 1,400,000 in 1958. About 80 per cent of the state population of indigo buntings was in the southern zone, 15 per cent in the central, and 5 per cent in the northern.

Because densities of indigo bunting populations were about the same in all census summers, we do not expect great population expansion in this species, but some increase should occur if the acreage of woody habitats continues to increase. The bunting was probably not abundant

in the primeval Illinois habitats of forest and prairie, and the original cutting of timber, because this cutting increased forest-edge and shrub habitat, probably favored the species.

Dickcissel.—One of the most abundant fringillids in Illinois, the dickcissel, was found (all census years) throughout the state in summer. Densities of dickcissel summer populations were consistently (all years and most habitats) highest in the central zone, lowest in the northern. Representative of this regional variation were recent densities of dickcissels in red clover fields: about 20 birds per 100 acres in the northern zone, 78 in the central, and 34 in the southern.

Favorite dickcissel habitats in summer were hayfields of all types, small grain and grassland habitats, edge shrubs, and hedgerows; dickcissels were found also in cornfields, soybean fields, plowed fields, orchards, and shrub-grown areas.

Population densities of the dickcissel in various summer habitats in central Illinois in 1957–1958 were 220.9 birds per 100 acres in edge shrubs, 163.5 in hedgerows, 115.8 in sweet clover, 93.4 in mixed hay (33.4 in 1907–1909), 77.9 in red clover (55.6 in 1907–1909), 80.6 in ungrazed grassland, 79.2 in fallow fields, 64.5 along drainage ditches, 28.8 in alfalfa, 22.3 in wheat fields (7.1 in 1907–1909), 17.8 in oats (6.8 in 1907–1909), and 8.2 in pastures (3.4 in 1907–1909). Why populations of the dickcissel were consistently much lower in alfalfa than in other types of hay is unknown; alfalfa was also the least preferred hay type for the redwinged blackbird. The dickcissel and the redwing show some similarity in the placement of their nests.

Despite high variability in dickcissel numbers from year to year, it is clear that the population increased greatly between 1909 and 1957. In June, 1909, there were estimated to be 1,700,000 dickcissels in the state; the 1907 population was lower (probably about 1,500,000). In 1957 and 1958, the central zone had, by our estimate, about 2,250,000 dickcissels; the state population numbered about 3,350,000 birds in 1957 and 3,850,000 in 1958. Populations in the northern zone (only 2 to 6 per cent of the state total) and in the southern zone (30 to 40 per cent)

were much more variable than those in the central zone.

The dickcissel is another species that has adapted well to cultivated habitats that replaced the original prairie. In 1957–1958, dickcissel densities were higher in fields of tame hay (as a group) than in the ungrazed prairie-like situations; total hay acreage increased between the two census periods. Even at the time of the early surveys, the dickcissel population was probably on the increase.

American Goldfinch.—In both summer and winter, the American goldfinch was recorded throughout the state. In all census years, populations tended to be most dense in the northern zone. In shrub-grown areas, for example, in the summers of 1957–1958, there were about 46 goldfinches per 100 acres in the northern zone of Illinois, 33 in the central zone, and 5 in the southern.

The goldfinch was found in nearly every summer habitat censused; shrubbery of all kinds, orchards, and ungrazed grasslands were particularly favored. Summer densities of goldfinch populations in various habitats in the northern zone in 1957–1958 were 167.5 birds per 100 acres in edge shrubs, 96.2 in orchards, 69.9 in ungrazed grassland, 46.4 in shrub-grown areas (29.1 in 1909), 7.3 in forest, 6.4 in pastures (2.1 in 1907–1909), 6.1 in oat fields (2.1 in 1909), and 4.3 in marshland.

Because of the paucity of data on woody habitats in central and northern Illinois for 1907–1909, there is little basis on which to speculate about population changes in this species. Southern Illinois summer populations, at least, were roughly comparable in 1907 and 1958 (about 500,000 birds in each year). For the entire state, we estimated, the June populations of goldfinches numbered about 880,000 birds in 1957 and 1,000,000 in 1958. While population densities were consistently highest in the north, the southern zone had most of the good goldfinch habitat of the state, and therefore a high percentage (as much as 47 per cent in 1958) of the state population.

In winter, highest populations of the goldfinch occurred in forests, shrubs of all types, in pastureland, fallow fields, and ungrazed grassland, and (in 1906–07) cornstalk habitat. No species in Illinois

showed more erratic fluctuations in population than the goldfinch; the winter distribution was particularly erratic. In the mild winter of 1906-07, there were, by our estimate, at least 1,600,000 goldfinches (January, 1907, population) in Illinois, most (about 90 per cent) of them in the northern and central zones. In January, 1957, the state population was the same as in June of that year, or about 900,000 birds, most (about 80 per cent) of them in the southern zone.

Savannah Sparrow.—In summer of both census periods, the savannah sparrow was encountered in the northern and central zones of Illinois. However, the population in the central zone in recent census years was sparse.

The savannah sparrow in summer was found in grassland habitats of all types, marsh, all hay crops, oat fields, and soybean fields; populations were highest (all census years) in pastures and ungrazed grassland. Population densities of the savannah sparrow in various habitats in northern Illinois 1957-1958 were 38.5 birds per 100 acres in mowed hay, 27.8 in shrub-grown areas, 23.5 in ungrazed grassland, 20.8 in pastures (5.7 in 1909), 13.6 in red clover, 13.0 in mixed hay (1.7 in 1909), 4.3 in alfalfa, 3.9 in sweet clover, 2.8 in marsh (5.2 in 1909), and 2.1 in fallow fields (16.5 in 1909). Alfalfa and sweet clover proved to be relatively poor habitats for this ground-nesting species. The meadow-like marshes that were more numerous in the early survey years than later may have been a fairly important habitat for the savannah sparrow.

The savannah sparrow population in the state probably increased somewhat between 1909 and 1957 despite a loss in pasture acreage. In June, 1909, there were, we estimated, 160,000 savannah sparrows in the state (about 20,000 in the central zone). In both 1957 and 1958, the June population numbered about 390,000 birds, most in the northern zone. The savannah sparrow greatly increased its population in hay habitats; there was a general increase in population density that may have had no relationship to habitat acreage changes.

In winter, the savannah sparrow was recorded only in the recent census years and in southern Illinois, where the population was all but negligible.

Grasshopper Sparrow.—In all census years, the grasshopper sparrow was encountered in summer throughout the state; population densities were consistently highest in the central zone and lowest in the southern. In red clover fields, there were about 4 grasshopper sparrows per 100 acres in the northern zone, 9 in the central, and only 2 in the southern.

In summer, the grasshopper sparrow occurred in all grassland and hay habitats, oat and wheat fields, soybean fields, cornfields, orchards, and shrub areas. Densities of grasshopper sparrow populations in the most favored summer habitats in central Illinois in 1957-1958 were 53.2 birds per 100 acres in sand prairie, 42.5 in mixed hay (16.7 in 1907-1909), 40.9 in alfalfa, 9.3 in pastures (3.4 in 1907-1909), and 8.9 in red clover (19.2 in 1907-1909). Populations of the grasshopper sparrow in fields of small grain changed between 1909 and 1957. In oat fields of the central zone, there were virtually no grasshopper sparrows in 1957-1958 (2.8 per 100 acres in 1907-1909); in wheat fields of this zone there were 1.6 grasshopper sparrows per 100 acres in 1957-1958 (1.1 in 1907-1909). Alfalfa, a relatively poor habitat for the savannah sparrow and a number of other grassland species, proved to be a high-density habitat for the grasshopper sparrow.

The grasshopper sparrow is a small species, and, except for the singing male, inconspicuous; in all likelihood, our density figures and population estimates are well below the true figures, but suitable for comparison within the study. Our data indicate that the grasshopper sparrow population did not change greatly between the two census periods. In June, 1909, we estimated, there were about 500,000 grasshopper sparrows in Illinois. The 1907 population was higher, probably exceeding 700,000 birds. June populations in 1957 and 1958 numbered, respectively, about 700,000 and 850,000 birds. In all years, the central zone had over 50 per cent of the state population; this latitudinal distribution was particularly marked in 1957-1958, when about 70-80 per cent of the Illinois grasshopper sparrows were in the central zone. The future for this species appears to be reasonably bright. Pasture acreage in Illinois continues to

decline, but hayfields offer a good reservoir habitat.

Vesper Sparrow.—In all of the summer censuses, the vesper sparrow was found in the northern and central zones and, in 1957, also in the southern zone. About 90 per cent of the state population was in the northern zone.

The vesper sparrow was recorded in summer in all grassland and hay habitats, fallow fields, small grain, soybeans, corn, plowed fields, shrubbery of all types, and orchards; edge shrubs, red clover fields, and shrub-grown areas were particularly favored by this species. Population densities of vesper sparrow populations in various habitats of the northern zone in 1957–1958 were 58.6 birds per 100 acres in edge shrub, 14.5 in red clover (8.9 in 1909), 12.4 in shrub-grown areas, 9.4 in ungrazed grassland, 8.8 in mowed hayfields, 5.8 in alfalfa, 5.7 in pastures (2.6 in 1909), 3.4 in corn (4.7 in 1909), and 2.9 in mixed hay (2.8 in 1909). The preference of the vesper sparrow for red clover was further indicated by the fact that, in the southern zone (the southern edge of the nesting range for this species), this sparrow was found only in red clover. The vesper sparrow, unlike most of the fringillids, occurred with fairly high frequency in bare-field habitats, the row crops and plowed fields.

Neither the state population of the vesper sparrow nor its distribution changed greatly between 1909 and 1957. In June, 1909, there were about 250,000 vesper sparrows in Illinois; the state population numbered about 390,000 in 1957 but only about 150,000 in 1958. The population of the southern zone probably did not exceed 10,000 birds in any year. Habitat changes between the two census periods should not have affected the vesper sparrow to any great extent; although the pasture acreage decreased, there was more red clover in 1957–1958 than in 1907–1909. Because the vesper sparrow nests in a greater variety of habitats than most of the open-field fringillids, and because it seems to favor even the bare-field habitats, it is surprising that this species did not show some gain in population. Other factors than habitat availability may have been responsible for holding the population at a low level.

Lark Sparrow.—In 1907–1909, the lark sparrow was found in all zones, but between 75 and 95 per cent of the state population was in the southern zone. By contrast, in 1957–1958, we recorded lark sparrows only in the central (about 90 per cent of the state population) and in the northern zone. To a large extent, the distribution of the lark sparrow is probably governed by the local distribution of sandy and other poor soils. In the recent surveys, we covered enough ground to be reasonably certain that the lark sparrow population in 1957–1958 in the southern zone was almost negligible by comparison with the 1907–1909 population in that zone.

Unlike virtually all of the other species censused, the lark sparrow showed no very decided habitat preference, perhaps partly because the soil requirement noted above overrides the vegetation requirement and partly because this sparrow nests in a broad variety of habitats, both on the ground and in trees. Population densities of the lark sparrow in various summer habitats in the southern zone for 1907–1909 were 4.1 birds per 100 acres in pastures, 2.5 in fallow fields, 2.2 in cornfields, 2.0 in wheat, and 1.6 in oats. Densities in various habitats (sandy and poor soil areas only) in central Illinois in 1957–1958 were 25.2 lark sparrows per 100 acres in hedgerows, 14.3 in plowed fields, 5.5 in fallow fields, 2.0 in shrub-grown areas, and 1.2 in pastures.

In June, 1909, by our estimate, there were about 500,000 lark sparrows in Illinois, of which 370,000 were in the southern zone. The 1907 population was lower, but it exceeded 300,000 birds. Summer populations numbered about 80,000 birds in 1957 and 70,000 in 1958, most of which were in the central zone. The lark sparrow is a versatile species in its nesting habits, and it is difficult to understand why the population declined so much; the great loss in southern Illinois is particularly puzzling. Here we can only point out the need for a detailed study of the biology of the lark sparrow in Illinois.

Slate-Colored Junco.—In both survey periods, the slate-colored junco was recorded in winter throughout Illinois, but about 90 per cent of the state population (all census years) was in the south-

ern zone; the numbers fell off sharply to the north. The junco was found in all of the winter habitats; edge shrubs, hedgerows, shrub-grown areas, and (in 1906-07) orchards had particularly high densities. Of the open-field habitats, fallow fields, ungrazed grasslands, cornfields of all types, and pastures were conspicuous favorites of the junco.

January populations of the junco in Illinois numbered, by our estimates, about 5,300,000 birds (4,400,000 in the southern zone) in 1907 (very mild weather) and 6,400,000 (5,900,000 in the southern zone) in 1957. The January population of 1957 was higher in most habitats than that of 1907; the 1957 population in the northern zone especially was high, about six times the 1907 level. These data fit a pattern observable in a number of other species—a trend toward higher winter populations at latitudes farther north in recent years. Published Christmas count records for central Illinois (Anon. 1900-1960) indicate that winter junco populations were neither unusually high nor low in 1906-07, 1956-57, and 1957-58. In February, 1958, the state population exceeded 10,000,000 juncos, and, because in the central zone the population was then almost four times the population in January, it was evident that northward migration was in progress, despite the severe weather conditions that prevailed. The high population of juncos in Illinois in February must have included a large number of migrants from wintering grounds south of Illinois.

Tree Sparrow.—In all census winters, the tree sparrow was found throughout Illinois. Unlike the junco, the tree sparrow was uniformly distributed in the state.

The tree sparrow occurred in virtually all of the winter habitats censused; like the junco, this sparrow especially favored edge shrubs and hedgerows, shrub areas, and, among open-field habitats, fallow fields and corn stubble. In 1906-07, the tree sparrow was much more abundant in corn stubble than in picked corn (corn-stalk) fields; the latter habitat was preferred by most species of winter residents.

Examination of Illinois Christmas count data (Anon. 1900-1960) showed that the tree sparrow population was more

highly variable than the junco population and that the number of tree sparrows wintering in Illinois was not unusual in 1906-07 or in 1957-58, but was abnormally high in 1956-57. The strip census data fit well with this picture. We estimated that January populations of the tree sparrow in Illinois numbered about 1,600,000 in 1907 and 6,900,000 in 1957. The February population in 1958 was about 2,000,000 birds, and there was no indication of northward migration within the state, though many migrants could already have moved north of Illinois.

Chipping Sparrow.—In 1907-1909, the chipping sparrow was found throughout Illinois in summer; in the later survey period, this species was not recorded in central Illinois, and the population in the other zones was vestigial. Even during the early surveys, the chipping sparrow population was highly variable from zone to zone and from year to year; the southern zone had the highest population. In 1957-1958, most of the Illinois chipping sparrows were in the northern zone.

Favorite summer habitats of the chipping sparrow were residential areas, orchards, and pastures; in 1907-1909, the chipping sparrow was found in a variety of woody and open-field habitats. In the half century between survey periods, chipping sparrows were probably not very abundant in Illinois, but the June population numbered, by our estimates, about 250,000 birds in 1909 (probably almost as many in 1907) and less than 50,000 in 1957 and 1958. Habitat acreage changes may have had little to do with the decline. Loss of orchards would seem to have been detrimental to the chipping sparrow. Another favorite habitat, residential areas, increased in acreage with no apparent benefit to the species.

Field Sparrow.—In all census years, the field sparrow was found throughout the state in summer and in the southern zone in winter. Summer populations tended to be most dense in the southern and central zones, the zones that had the bulk of the optimum habitat; in all years, most of the state population was in the southern zone.

Favorite summer habitats for the field sparrow were shrubs of all types, hedgerows, orchards, and pastures. Densities of

field sparrow populations in various habitats in the southern zone in 1957-1958 were 200.0 per 100 acres in edge shrubs, 91.3 in hedgerows, 53.4 along drainage ditches, 37.4 in shrub-grown areas (46.9 in 1907-1909), 23.1 in orchards (59.7 in 1907-1909), 19.9 in pastures (8.6 in 1907-1909), 11.7 in fallow fields (8.8 in 1907-1909), 10.2 in ungrazed grasslands, 4.7 in forest (28.4 in 1907-1909), 4.4 in wheat (3.5 in 1907-1909), and 1.5 in hayfields of all types (3.0 in 1907-1909). Although many of the density figures indicated higher populations for the early than for the later census years, the density in pastureland, a declining habitat, was notably higher for 1957-1958 than for 1907-1909.

In June, 1909, the state population of field sparrows numbered, by our estimate, at least 2,100,000 birds (75 per cent in the southern zone); the 1907 population was lower but probably exceeded 1,700,000 (these estimates do not include edge shrub or hedge populations). June populations in 1957 and 1958 were, respectively, about 1,400,000 and 1,000,000 birds (62 per cent in the southern zone, both years).

Habitat acreage changes probably had some effect on the field sparrow population. In the summers of 1907 and 1909, southern Illinois orchards alone accounted for over 100,000 birds, in contrast to 15,000 or less in 1957-1958. This change represents both an acreage loss and a loss in population density of the field sparrow in orchards. Though several insectivorous and frugivorous species showed density reductions in orchards between 1909 and 1957, the field sparrow is one of the few fringillids that declined in orchard habitat.

The increase in forest and shrub acreage between 1909 and 1957 would have helped the field sparrow population if population density had kept pace with the acreage increase in these favorable habitats.

Winter habitats for the field sparrow were the winter counterparts of the summer habitats in southern Illinois. The winter population of the field sparrow in Illinois has probably never been very large. We estimated January populations of this sparrow to be about 85,000 birds in 1907

and 190,000 in 1957. The population in February, 1958, was almost negligible (about 10,000 birds), and there was no indication of northward migration. Field sparrows, like birds of a number of other species, probably drifted farther southward in late winter.

Song Sparrow.— In the recent surveys, the song sparrow was found throughout Illinois in both summer and winter. In 1907-1909, the species was widely distributed in winter, but it did not occur in the southern zone in summer. In all census summers, the song sparrow population was most dense in the northern zone. In shrub areas, the northern zone had about 37 song sparrows per 100 acres, while the central zone had only 8 per 100 acres; the southern zone had only a negligible population. Densities of song sparrow populations in various habitats in the northern zone in the summers of 1957-1958 were 95.9 birds per 100 acres in edge shrubs, 62.9 in hedgerows, 37.1 in shrub-grown areas, 32.0 along drainage ditches, 11.4 in marshes (5.2 in 1909), 11.0 in orchards, 5.2 in ungrazed grasslands (20.3 in 1909), 3.9 in sweet clover, 3.2 in pastures, 2.7 in red clover, 1.7 in forest, and 1.4 in mixed hay (2.8 in 1909). Along with its range extension southward, the song sparrow population in Illinois probably increased at least slightly between 1909 and 1957. By our estimate, June populations of the song sparrow in Illinois numbered about 180,000 birds in 1909, 250,000 in 1957, and 290,000 in 1958. At least 2,000,000 acres of Illinois land were not accounted for in these estimates, and this acreage—probably various marginal habitats—may include a significant amount of prime song sparrow habitat. Thus, the actual state population may be much higher than our estimates for this species. Habitat acreage changes between the two census periods had only slight effect on the song sparrow population. Loss of marshland, orchards, and pasture was largely balanced by increase in forest edge.

In winter, though song sparrows occurred throughout Illinois (all census years), most of the state population was in the southern zone, where the winter population exceeded the summer population. Ungrazed grasslands, shrub habitats, marshes, and drainage ditches were espe-

cially preferred winter habitats of the song sparrow. By our estimates, January populations of song sparrows in Illinois numbered about 350,000 birds in 1907 (88 per cent in the southern zone) and 475,000 in 1957 (70 per cent in the southern zone). Like many other species, the song sparrow may be wintering farther north in greater numbers now than in earlier years.

This sparrow may be more tolerant of cold than many other migratory fringilids. As many as 70,000 song sparrows wintered in the northern zone, and, unlike the birds of many of the species considered in this report, song sparrows did not appear to move southward in late winter shortly before the onset of spring migration. Our data indicate that, despite severe winter weather, song sparrows were migrating north in great numbers in February, 1958, when the southern population was swelled to about 900,000 birds, presumably by an influx of migrants from farther south.

Lapland Longspur.—In the first winter survey (1906–07), the Lapland longspur was found only in the northern zone of Illinois, but, in 1956–57, this species was abundant in both the northern and central zones; in 1957–58, it was recorded throughout the state. In recent census years, January population densities were highest in the central zone.

Like the horned lark, the Lapland longspur in winter particularly favored open habitats with relatively little cover; apparently some low cover was important in the habitat. In the central zone, population densities in recent census years were about 84 birds per 100 acres in cornfields, 51 in alfalfa, 42 in soybean stubble, and 28 in small grain stubble, but only 5 in plowed fields.

In January, 1907, by our estimate, there were about 700,000 longspurs in Illinois, all in the northern zone. In January, 1957, the state population numbered about 4,800,000 birds, most of them (86 per cent) in the central zone and none in the southern. Longspur populations are known to be extremely variable, and perhaps the great difference between the 1907 and 1957 populations falls within the range of "normal" year-to-year variation. Both winters were mild, at least until late

January. In recent years (1956–1962), we have found the longspur to be common in central Illinois every winter, and it is possible that the species is extending its winter range southward, or perhaps eastward. Habitat changes probably favored such an extension. Cornfields, which now make up a large part of the Lapland longspur habitat in winter, were of little value to the longspur in earlier times when hand-harvesting methods left stalks standing; the cover was too dense and tall for this species. The initiation of mechanical harvesting methods, which flatten stalks to the ground, and the beginning of soybean agriculture created millions of acres of prime winter habitat for the longspur in Illinois.

In February, 1958, longspur distribution in the state had a pattern not seen previously. In this time of extremely adverse weather conditions, longspurs (probably about 5,700,000) occurred throughout the state, but in greatest numbers in the southern zone (about 3,200,000). Coincident with a great increase in the population of the southern zone, the number of longspurs in central Illinois fell from the January level of 4,150,000 to about 1,900,000. Obviously, the population had shifted southward in late winter, but whether this is an annual occurrence remains to be determined.

DISCUSSION

Much of the world's ornithological literature deals expressly with variations in populations of wild birds, but still we know relatively little about rates of change in these populations. We know that, in time, even the species is transient; examining the fossil record (Wetmore 1940), we find no positive evidence that any North American bird species now extant has survived more than about 10,000,000 years. In less time—since the beginning of the Pleistocene, perhaps a million years ago—the number of species in the North American avifauna has probably been reduced by about one-fourth. In much less time, many important faunal changes have become matters of historical record. In the Illinois avifauna alone (Smith & Parmalee 1955), we could note the disappearance, within the past 100 years, of at least a dozen species and the

establishment in numbers of half a dozen more. Looking back, we perceive faunal changes and acknowledge that they are continuing. The fauna that we study now is an ever-changing heritage from the past. Though in a broad sense evolution has no beginning and no end, it has directions that are affected by factors untold in number.

The annual fluctuations that characterize all bird populations make it particularly difficult to identify changes that have direction and relative permanence. Certain faunal changes (for example, range extension by such conspicuous species as the cardinal and the mockingbird) are easily detected even in their early stages. Other faunal changes (for example, the decline leading to extinction of a species) may be noticed only in the later stages of the change. Some trends may be detected only in the light of periodic population measurements.

The need for detailed censuses of birds was recognized long ago, but, despite the initiation of the Christmas counts in 1900 (Chapman 1900:192), two nationwide summer censuses sponsored by the United States Biological Survey (Cooke 1915, 1916), and subsequent development of a regular program for censusing breeding birds (Hickey 1937), there are still relatively few bird population data available for much of North America. Most recorded population measurements of high quality are provincial in avifaunal, ecological, and geographical scope and span only relatively short periods of time. Information for habitats other than forest is particularly scarce, though the census program is expanding steadily through the voluntary efforts of many ornithologists.

The value of systematic bird censuses increases as the years pass, for without some reference to the past we cannot see the trends of evolution; we can see neither the magnitude nor the direction of change. In terms of quantitative data on bird populations in North America, we have few reference points before 1915. In view of the paucity of quantitative data, and the habitat changes that have occurred in the past half century, the efforts of Stephen A. Forbes and Alfred O. Gross to provide detailed information on the bird life of 1906-1909 in virtually every habitat in

Illinois appear particularly farseeing and commendable.

Almost inevitably, the field biologist, because he deals with many variables, becomes uneasy about the adequacy of his data. In this paper, our interpretations are based on a record of only 4 years, 2 early in this century and 2 in midcentury. For many species of birds, the temporary fluctuation in population between two consecutive census years might far exceed any irreversible directional change that would occur in a period of 50 years or more. Fully recognizing the possibility of confusing short-term fluctuations with relatively permanent changes, we have still accepted the differences between the 1906-1909 and 1956-1958 data largely at face value. In our conclusions, we have been guided for the most part by the strip census records. The data presented in tables and text are always open to re-evaluation, and the reader should bear this fact in mind.

Events Previous to 1800

Following the last glaciation—perhaps 10,000 years ago (Livesay 1951:23)—and before white settlement, there were probably few types of bird habitats in the area that was to become the state of Illinois. In succession, the melting glaciers gave way to open lakes, to marshes, and then largely to drier habitats of grassland and forest. The present Illinois soil types indicate that in pre-Columbian times and as late as about 1800 approximately 14,000,000 acres were forested (King & Winters 1952:20) and between 21,000,000 and 22,000,000 acres were primarily prairie grassland. Included in these total acreages there were probably more than the 1,400,000 acres of wetlands reported by Shaw & Fredine (1956:5) for a later period. Naturally disturbed forest areas (areas disturbed by fire, flood, or erosion) undoubtedly gave rise to some shrub habitat, but the acreage of this habitat is inestimable.

Quantitatively, at least, the Illinois avifauna of 1800 and before is unknown. If we could assume bird population densities for 1800 similar to those of the early 1900's for the acreages in the primary habitats of forest, marsh, and prairie, then in 1800 and probably many years before

the Illinois area would have had a breeding bird population of about 97,000,000 birds—53,000,000 in forest, 7,500,000 in marsh, and 37,000,000 on the prairie.

In the years previous to 1800, man was a minor force in effecting faunal changes in the Illinois country. The Indian inhabitants of this area cultivated some land, probably only a few thousand acres. Marquette reported that the Illini tribes numbered 8,000 or 9,000 persons in 1670 (Temple 1958:14). The Indian population of the area dwindled through the 18th century. Zebulon M. Pike reported that in 1805 the Sauks and Foxes, who had largely replaced the Illinois tribes, together numbered only about 4,600 persons (Temple 1958:99–101). These thin populations had probably transformed but little of the natural habitats of the area.

Development of Managed Habitats

White settlement of the Illinois country, which began about 1700 (King & Winters 1952:10), was still negligible by 1800. In 1798, there were about 5,500 whites in the area that later formed the states of Illinois, Indiana, Wisconsin, and Michigan (Hagan 1958:3). In the following century, the 19th, most of the Illinois lands came under cultivation. In that century, perhaps as many as 10,000,000 acres of forest were removed. If our hypothetical estimate of the bird population of 1800 was correct, the decimation of Illinois forests in approximately 100 years was tantamount to the elimination of about 38,000,000 breeding birds from the state. Hicks (1935:306) suggested that the original forest in eastern North America, because it offered relatively little edge, may have been poor bird habitat. Even if it was poor habitat and our estimate for 1800 was considerably high, 19th century deforestation must have taken a tremendous toll of Illinois birds. Areas adjacent to the Illinois country were also coming under the plow, and forests that remained must have been quickly populated to saturation.

In the 19th century, also, grassland and marsh habitats were being transformed. By 1830, Illinois had nearly 160,000 whites (Anon. 1832:38). By 1850, it had 12,000,000 acres in farmland (Anon. 1936:151); the farm acreage almost dou-

bled in the next decade and reached about 33,000,000 by 1900. The acreage of corn, oats, and cultivated hay more than doubled between 1866 and 1900 (Anon. 1936:153, 155, 165), supplanting most of what remained of the original 36,000,000 acres of natural habitats. What was left by 1900 was about 3,500,000 to 4,000,000 acres of forest (some of it grazed), about a million acres of prairie grasslands and marsh combined, and a vast expanse of land in various stages of cultivation. Most of the cultivated habitats, new to Illinois, were without an avifauna. Some prairie species held on in marginal prairie acreage, and for a number of prairie birds there was probably little hardship in the transition from wild prairie to tame or cultivated hay, or to pastureland that was not overgrazed. In 1900, the row crops, plowed fields, and small grain fields, which occupied nearly 20,000,000 acres, were for breeding birds largely a void to be partially filled later by the horned lark.

Particularly in southern Illinois, deforested areas that did not come immediately under cultivation were quickly occupied by a shrub flora and avifauna. The century that saw the Illinois forests decimated brought approximately 300,000 acres of orchards into being, and, between the marginal forest species and the marginal prairie species of birds, the orchards had a ready-made avifauna. In that century, too, a notable acreage (probably about 350,000 acres by 1900) of human residential habitat developed in Illinois. Much of it rural and adjacent to orchards, residential habitat usually had tree and shrub cover of its own that claimed some segments of the forest and shrub avifaunas.

By 1900, over much of Illinois and the Midwest, there was beginning to be an agriculture-adapted avifauna. The trends of change were established, and the ensuing 60 years saw them continued. As in previous times, some species adapted to the change. In a few cases, man unwittingly adapted the environment to suit the species.

The past 150 years in Illinois have seen the beginning and development of a specialized kind of evolution. Albeit unwitting, it is, nonetheless, evolution by management. The pattern of change is not

basically different from that in previous times, when other species of animals probably "guided" evolution to some extent, though the rate of change may never before have been so fast.

In little more than 100 years, the Illinois landscape changed immensely, from a few relatively high density habitats with an estimated June population (primarily nesting adults) possibly as high as 97,000,000 birds in 1800 to the diversified, managed habitats of 1907, which supported about 61,000,000 birds. In the next half century, the state avian population changed but little in total number. There is more to the picture of changing bird populations in Illinois than these gross population figures can tell. None of the population changes, of course, represented a general decrease or a general increase in the whole population. Of the 40 most abundant species of birds in the state, 17 showed notable population increases in the half century, 17 showed decreases, and 6 had about the same populations in 1907-1909 as in 1957-1958. There was selection, adaptation, extirpation; in short, there was evolution continuing. If we emphasize the changes of the half century between the two surveys, it is only because of the temporal limits of our data, for the patterns of change that led into the 19th century are continuing still.

Specific Changes in Avifauna

The basic patterns of change in the Illinois avifauna during the five decades between the two surveys can best be presented by example. For many of the changes observed we can offer no explanation, and, in all cases, the reader should bear in mind that it is easy to oversimplify so complex a phenomenon as evolution. Unless otherwise stated, the population figures presented represent June populations, primarily the adult nesting populations.

Earlier, we noted that there was no ready-made avifauna for most of the newly developing, managed habitats of 19th century Illinois. An increasingly greater use of some of these habitats by certain species of birds, both exotic and native, was a dominant trend of many decades.

A case in point was the utilization of residential habitat by exotic species. Intro-

duced species thrive in managed habitats, and arrival of the house sparrow on the continent could not have been timed much better to take advantage of the swelling acreage of residential habitat. In 1907-1909, the house sparrow was already a part of the Illinois avifauna, and was, in fact, probably the most abundant species in the state, with a population of at least 5,300,000 birds. The sparrow population was only slightly higher in 1957-1958 than in 1907-1909; in the intervening years, the house sparrow, like man, had become increasingly urban in distribution. The starling, which was not even present in the state until about 1926, well after the early surveys, attained by 1957-1958 a state breeding population of at least 3,100,000 birds, most of them in residential areas.

What effect the starlings had on other cavity-nesting species can only be surmised. At least partly coincidental with increasingly greater numbers of starlings, flicker populations in the state fell from about 2,300,000 in 1909 to 300,000 in 1957, and the numbers of red-headed woodpeckers declined from 1,300,000 in 1909 to 130,000 in 1958. These native birds are not strictly forest species, but inhabitants of marginal, savanna-type, or even residential habitats, and they almost certainly came into competition with the starling. In recent years, flicker populations in residential habitat were inversely proportional to the starling population, and starling numbers are presumably still increasing. Such native cavity nesters as the red-bellied and hairy woodpeckers, which are more restricted to the natural forest habitat, have not had to compete much with the starling and have shown no population decline. The evidence against the starling, though circumstantial, appears incriminating. During the habitat changes of the 19th and early 20th centuries, some native species found a niche in man's residential habitat, but, to the medium-sized cavity nesters in this group, the introduction of the starling was destructive.

These exotic species were adapted to the residential habitat even before their introduction into Illinois. Two native species, the chimney swift and purple martin, were probably adapted to the urban situation

long before 1900. From a broad ecological background in 1907–1909, the robin population in Illinois had, by 1957–1958, come to survive almost entirely in residential habitat. Like the human population, the robin population has been concentrated particularly in northern Illinois.

Adaptive utilization of cultivated habitats extended to some open-country birds. Two examples deserve special discussion here.

At least since the time of the early surveys (and presumably in previous ages), redwinged blackbird populations have attained their maximum densities in cattail marshes. In 1907–1909, though redwings occurred in prairie, hayfields, and other habitats, most of the state population, which numbered about 5,000,000 birds, was in marshland. By 1957, the population numbered over 8,000,000 (11,000,000 in 1958), and most of the Illinois population was in cultivated habitats, particularly mixed hay. In the period 1907–1957, marshland, which had been largely restricted to the northern half of the state, dwindled to a tenth of its 1907 acreage, and sod grasslands gave way increasingly to cultivated hay throughout the state. In this more widely distributed habitat, the redwing population swelled. The redwing may be expanding its utilization of secondary habitats even further. For instance, there is clear indication of increased use by the redwing of small grain fields, a habitat reservoir amounting to several million acres. This trend promises further increase in the redwinged blackbird population.

Even more spectacular than the population increase of the redwinged blackbird was the change in population of the horned lark. Between these two species, there was a subtle, but basic, difference in the mechanism of change. For the redwing, marshes were, and still are, the favorite habitat (judged from population densities); yet the redwing invaded a secondary habitat that by 1957 supported most of the population. For the horned lark, man unwittingly created what proved to be an "optimum" habitat. Before white settlement, the horned lark probably resided in the relatively barren parts of the prairie grassland, and its population was probably not very great. The

lark avoids tall cover, and bare ground is apparently an important part of its habitat. The great 19th century expansion of agriculture opened a vast land to the lark. With white settlement, increased grazing on the primary grasslands improved, for the lark, the original habitat, but even from pastures the lark moved increasingly to tilled land. The newly opened habitats were not saturated in 1907–1909 when the Illinois horned lark population was under 1,500,000 birds; by 1957–1958 there were about 5,000,000 horned larks in the state. For the horned lark, this population change in Illinois was probably representative of changes in other parts of the Midwest (Hicks 1935:308).

Specialization in Managed Habitats

The adaptation of bird species to the cultivated scene was but one major force in shaping the present avifauna. The cultivated habitats themselves became more specialized through changes in management.

Here, for one example, we can refer to changes in orchard management to show at least two ways in which bird populations were affected. While the density of the total bird population in orchards was about the same in 1957–1958 as in 1907–1909, certain species, principally insectivorous and frugivorous types such as the eastern kingbird, robin, blue jay, the mimids, and orchard oriole, tended to disappear from the orchard avifauna. At least some of these species maintained or even increased their population densities in other habitats. Why they should have declined in orchard habitat particularly is a problem that needs further study. The increased use of insecticides in orchards and the development of organic insecticides may have had some bearing on the change. Much of the orchard acreage in 19th and early 20th century Illinois was composed of noncommercial farmyard orchards that probably received little insecticide spraying. Later these farmyard orchards gave way largely to commercial stands that received regular treatment with insecticides.

Both the change in size of individual orchards, from family farm plots to large commercial stands, and the great decline in total acreage of orchards had their effect on the avifauna. The commercial tracts of 1957–1958 had a decidedly uni-



Fig. 29.—Southern Illinois landscape in June, 1907. The distribution of open fields and scattered clumps of shrubs and trees suggests a kind of savanna area. This type of cover distribution greatly favored a large variety of bird species. The loss of this habitat arrangement in recent times has contributed to a loss of avifaunal variety in Illinois. The photograph was taken 4 miles west of Shettlerville, Hardin County, June 28, 1907, by Alfred O. Gross.

form aspect and offered much less edge than did the small farm plots of previous decades.

To many species of birds, edge or marginal habitats are extremely important; after 1900, we entered an era of increasing field size and agricultural specialization in which edge habitats were diminished. The practice of removing hedgerows and other field-edge vegetation, as well as isolated trees within cultivated fields, became increasingly prevalent. Part of the modern practice of clean cultivation is the reduction of weeds in pastures and crops of all kinds through mowing or the use of chemicals; this practice may affect bird populations by erasing some nesting and foraging niches (Scott 1958:389). Now even fences are being eliminated from field edges in many parts of the state. Elimination of these fences in effect results in the elimination of a multitude of singing perches for birds. Its influence, if any, on bird life in the state is a subject that needs research.

In the late 19th and early 20th centuries, much of the land of Illinois had

the aspect of a kind of savanna, figs. 29 and 30. This savanna-type habitat, a transitional stage between the natural post-glacial habitats and the specialized block terrain of agricultural management, has been largely eliminated. Just as 19th century deforestation removed a segment of the fauna from large areas of the state, so 20th century elimination of savanna-type habitat removed another group of birds from extensive areas.

An important change in the Illinois avifauna during several recent decades was the waning, on a massive scale, of certain bird populations, particularly in the southern zone of Illinois. Many species were involved in this change, including at least the following: upland plover, yellow-billed cuckoo, mourning dove, flicker, red-headed woodpecker, eastern kingbird, blue jay, mockingbird, brown thrasher, robin, orchard oriole, lark sparrow, chipping sparrow, and field sparrow. For all of these species (combined) the net population loss in southern Illinois between 1909 and 1957 amounted to 4,000,000 breeding birds (minimum estimate).

Most of the species involved in this decline have at least one major ecological characteristic in common: except for the upland plover they are species of marginal, edge, or savanna-type habitats. Most of them are, therefore, species that probably increased greatly in population after 1800 as the land was transformed from its primeval state and broken into small farm

tracts. These species probably reached a peak around the turn of the century. Their decline began after 1900, as the number of farms and the acreage of sod grassland decreased, as cultivated fields increased in size, and as clean farming methods removed edge shrubs, solitary shade trees, and family orchards. Most of these habitat changes are still continuing.



Fig. 30.—Landscape near the Ohio River, Hardin County, southern Illinois, 1907 and 1963. Upper picture taken 3 miles west of Cave-in-Rock, July 1, 1907, by Alfred O. Gross. Lower picture, same area as upper picture; taken May 19, 1963, by Richard R. Graber. Timber is filling in the old savanna-type habitat. The barn in the distance at the left in lower picture was built on the site of the barn shown in the 1907 picture. This farm has been owned by the same family for many years.

Population Density and Avifaunal Variety

The increased specialization in managed habitats, with consequent diminishing of the savanna-type habitat, was only one ecological change that effected a loss of avifaunal variety in Illinois. Another ecological change having a similar effect was the adaptation of particular species to managed habitats.

If we examine the bird habitats and their associated faunas, we can see a direct relationship between the complexity of a habitat and the complexity of its avifauna. Row crops, which offered few niches and few types of niches for birds, were the poorest of the habitats both in numbers of birds and numbers of species. Woody habitats, which offered many niches and many types of niches for birds, supported high populations and varied avifaunas.

Beyond this primary direct relationship between density and variety, which can be seen in the whole gamut of habitats and avifaunas, another relationship between population density and faunal variety characterizes managed habitats only. By reducing floral variety in a habitat, man increases habitat specialization, therefore faunal specialization, and, in the transition

from natural to managed habitats, avifaunal variety tends to decline while population density tends to increase.

The basic difference between natural and managed habitats can best be illustrated with specific examples by considering the faunal characteristics of a natural habitat and its managed counterpart. Thus, uncultivated grasslands supported a greater variety of common bird species than did the hay crops, but the hay crops supported denser populations. Residential habitat, a modified type of forest, supported much denser populations of birds, but a much smaller variety of species than natural forest. The greater the degree of specialization in the habitat and its constituent avifauna, the higher the population density can be.

Cause and effect in the relationship between population density and avifaunal variety are difficult to establish, but ultimately they relate to the variety and number of niches that a habitat offers and to the interspecific competition for these niches. Characteristically, managed habitats offer a large number of niches, even though a small number of niche types, and the bird species best adapted to these niches occupy them so completely as to

Table 56.—Estimates of breeding populations of common species of birds in Illinois, 1909 and 1957. The estimates are for all acres of the habitats accounted for in this study. The species listed comprised about 70 per cent of the birds in these habitats in the years indicated.

1909		1957	
Species	Number	Species	Number
House sparrow	5,300,000	Redwinged blackbird	8,400,000
Redwinged blackbird	5,100,000	House sparrow	6,100,000
Common grackle	4,100,000	Horned lark	5,600,000
Meadowlark (spp.)	4,000,000	Meadowlark (spp.)	3,800,000
Mourning dove	2,500,000	Common grackle	3,600,000
Yellow-shafted flicker	2,300,000	Dickcissel	3,400,000
Field sparrow	2,100,000	Starling	3,100,000
Robin	1,900,000	Mourning dove	2,000,000
Brown-headed cowbird	1,800,000	Bobolink	1,900,000
Dickcissel	1,700,000		
Brown thrasher	1,600,000		
Blue jay	1,600,000		
Red-headed woodpecker	1,300,000		
Common crow	1,200,000		
Bobolink	1,200,000		
Indigo bunting	850,000		
Horned lark	840,000		
Bobwhite	840,000		
Total	40,230,000	Total	37,900,000

exclude other species of birds. The end result of such occupation is an avifauna with high population density but little variety. Pertinent here is the fact that in each of the managed high density habitats used as examples above (hay crops and residential areas) part of the bird population was composed of species (purple martin, house sparrow, starling, and redwinged blackbird) that show a high degree of intra-specific tolerance. It is such species, particularly, that increased in population after 1909. We must bear in mind that managed habitats, which have poor avifaunal variety, are the expanding habitats. Since the turn of the century, the acreage of cultivated hay has grown as the acreage of prairie grasslands has dwindled.

The trend toward specialization of habitats and their associated avifaunas (elimination of savanna-type habitat was a parallel trend) tended to reduce the number of bird species that could be classed as common in the state. A reduction in common species has become apparent even since 1909. If we arbitrarily define the common species as those comprising 70 per cent of the state population, we find that there were, in the Illinois avifauna, 18 common species (about 40,000,000 birds) in 1907-1909 and only 14 common species (42,500,000 birds) in 1957-1958. Data for 1909 and 1957, the years of best coverage, show an even greater difference in avifaunal variety, table 56.

Population Changes and Latitude

Although specialization of habitats and adaptation by particular species to these habitats were dominant forces of change in shaping the present Illinois avifauna, certain special changes were important enough to deserve elaboration. We noted earlier that a number of species of birds suffered population losses, particularly in the southern zone of the state. No single factor could account for the waning populations in all of these species. The populations of most of these species had been highest in 1907-1909 in the southern zone, and therefore that was the zone in which they had the most population to lose. Most of these species lost population in other zones, also, but a few—for example, the catbird and robin—actually increased their northern populations, while

losing in the south. Others lost proportionately less in the northern zone than in the southern. The brown thrasher population, for example, fell from about 160,000 birds (1907-1909) to 130,000 (1957-1958) in the northern zone (about 20 per cent loss), but from 800,000 to 180,000 in the southern zone (about 80 per cent loss). The effect of these specific changes can be seen and expressed in terms of the entire state population of birds, for, between 1909 and 1957, the breeding-bird populations of northern and central Illinois actually increased, while the breeding-bird population in the southern zone declined, or, at best, merely held its own. Why, within a species, did the population in the northern zone survive better than that in the southern? This question suggests another group of problems in Illinois ornithology that need further investigation. It is a mistake to assume that all of the species showing decline are responding to the same factors, though to some extent they may be.

The fact that the population losses varied with latitude suggests the possibility of climatic influences on the populations. The continent has probably been in a generally warming trend since the last glaciation; the temperature climb has been studied in detail since 1885 (Conover 1953). How, or if, this climatic warming has affected survival of breeding birds remains to be determined. Pertinent here are the notable changes in winter distribution of Illinois birds. Several species, including the mourning dove, mockingbird, robin, the meadowlarks, redwinged blackbird, swamp sparrow, and song sparrow, either extended their winter range northward in the state between 1909 and 1957 or wintered in Illinois in larger numbers in 1957-58 than in 1906-07. The winter (January) population of birds in Illinois increased from about 30,000,000 in 1907 to 55,000,000 in 1957. The factor or factors that effected population changes in the state winter population may also have influenced the breeding population.

Range Extensions

Among the types of change in the Illinois avifauna between 1909 and 1957, range extensions by a few species deserve

special mention. Of the common species censused, at least seven, all but one primarily southern forest species (turkey vulture, red-bellied woodpecker, Acadian flycatcher, tufted titmouse, Bell's vireo, cardinal, mockingbird, and probably the Carolina chickadee), extended their breeding range northward, and four, all icterids (bobolink, western meadowlark, yellow-headed blackbird, and Brewer's blackbird), extended their range southward or southeastward. The larger number of species moving north than south probably reflected the fact that deciduous habitat species were more numerous in the south. In addition to the species that made range extensions, there were a few species that greatly increased their breeding populations in one zone particularly. Probably the most notable example was the barn swallow, which enlarged its southern zone population tremendously from a very low level in 1907-1909.

In most cases, range extensions occurred from saturation or near-saturation populations in adjacent areas. The red-bellied woodpecker, for instance, was essentially a southern species in 1907-1909, with a saturation population in its primary habitat (forest) of about 5 birds per 100 acres. By 1957, this species had attained populations of the same density in the central zone and was still spreading northward, though populations in the northern zone were sparse (1 bird or less per 100 acres). At least two species, the turkey vulture and mockingbird, spread their populations northward despite thinning in the southern zone.

The range extensions of the several species of icterids mentioned above fit a broad pattern of change. All of these species experienced notable population increases between 1909 and 1957; all are marsh-inhabiting or open-field representatives of the blackbird family. Such a consistent trend toward population increase among the species of one family suggests the possibility of some particular genetic vigor, or at least a genetic unity that makes them all favorably responsive to the changes that man has wrought. The grackle, which qualifies both genetically and ecologically for this group, merely held its own between the two survey periods, but it found a niche in the expand-

ing urban habitat and should, in time, increase; the two strictly arboreal members of the family, the orchard oriole and the Baltimore oriole, suffered population decline.

Habitats and the Future of the Avifauna

In a very general way, we have traced the development of our present Illinois avifauna. To know more precisely where the avifauna is in its sequence of development, and what we might expect in the way of avifaunal changes in the near future, we need to consider in more detail the relative availability, and the value to birds, of various Illinois habitats. We can evaluate a habitat both in terms of the number of birds it supports and the number of species it supports. If we arrange the habitats according to the number of breeding birds they supported, listing those with highest population densities first, the sequence for 1957-1958 was urban residential areas, marsh, shrub, orchard, hay crops, forest, grassland, oats, wheat, the row crops, and bare-field or plowed ground. The same habitats arranged in order of decreasing avifaunal variety were forest, shrub, orchard, urban residential areas, marsh, grassland, hay crops, oats, wheat, row crops, and bare-field or plowed ground.

Row crops comprised over a third of the state acreage in 1957-1958 and are unlikely to diminish in acreage in the foreseeable future. These crops have some value as foraging habitats for several species of birds, but there is no indication that species other than the horned lark depend significantly for their survival on this vast acreage.

Acreages of small grain crops, particularly oats, declined between 1930 and 1957, and most of the lost acreage of these crops went into row crops. The change represents a loss to the Illinois avifauna in terms of both numbers of birds and faunal variety. However, no species of bird is now entirely dependent upon the small grain habitats; these habitats form a kind of overflow area for species that usually attain higher population densities in hay crops and grassland.

If hay and grasslands disappear, part of the avifauna, particularly adaptive species

such as the redwing, may survive principally in small grain fields. The redwing population, already somewhat in need of control, may expand even further in small grain habitats; small grain acreage in the coming years should not decline much below its present level.

Hay crops as a group, because they combine high population densities with large acreage, accounted in 1957-1958 for over 20 per cent of the state bird population, or at least 13,000,000 birds (in contrast to 5,000,000 or 6,000,000 in 1907-1909). In the 100 years before 1957, cultivated hay was an expanding habitat, replacing principally wild hay and pastureland. The change tended to favor a few species, especially the redwinged blackbird and the dickcissel, and to increase the total number of birds in the state, while reducing the variety of common species in the areas in which the change took place. The change is continuing, and pastureland acreage is falling steadily, as livestock is being confined more and more to smaller feedlots. Coincidentally, the hay crops have been made more specialized. Much of the mixed hay acreage has given way to alfalfa, a poorer habitat for some of the prairie birds. In recent years, there has been some experimentation with other types of legume forage plants; if present hay types should ever give way to viny legumes, the hayfield avifauna would suffer greatly.

Prairie marshland, the habitat with the second highest population density of birds, had all but disappeared from the state by 1957-1958 (60,000 acres in contrast to 560,000 in 1907), but it accounted for over a million birds, including a variety of species not adapted to other habitats. In the immediate future, the remnant marshland may be safe, but, as the human population expands and the land available for food production declines, pressure will come for the elimination of marshes and other uncultivated open-field habitats. Marshland acreage could actually be increased in the state, especially near large reservoirs. Because of the specialized character of the fauna of marshland, conservationists should encourage both the development of new marshland areas and the preservation of the existing marshland.

The acreage of shrub-grown areas,

which in 1957-1958 accounted for at least 2,000,000 birds in the state, probably increased slightly between 1909 and 1957, but it may decline seriously in the coming decades. Land-use patterns over most of the state are more stabilized now than they were even 50 years ago. Most shrub-grown habitat constitutes a transitional habitat that usually gives way to forest and depends on change of one sort or another for its continued existence. Areas now in shrubs are growing into forest, and the principal sources of shrub land (deforestation as it was formerly practiced and retirement of cultivated fields) have been largely cut off. Forest will continue to be harvested, but the harvest methods now most widely used (not the same as when trees were removed over great tracts of land) do not lead to shrub land. The amount of Illinois shrub land maintained by edaphic or topographic conditions is negligible. In addition, the acreage of edge shrubs (fencerows and roadsides) and hedgerows is rapidly being greatly reduced. Edge shrubs and hedgerows may have a higher population density of birds than any other habitat in the state, and it is particularly regrettable that these habitats are being removed in an era when there is no shortage of food-producing acreage. Though of very limited acreage (less than 100,000 acres), these edge habitats bring faunal variety to vast areas of open-field habitat where the fauna would otherwise be very limited; from the standpoint of efficient use of space for increasing populations of native species of birds, probably no easily obtainable habitat is superior.

Fortunately, many shrub-inhabiting species can survive in forest understorey, but there are some, such as the prairie warbler, Traill's flycatcher, and Bachman's sparrow, which require open shrub arrangements; few shrub-dwelling species attain such high population densities in forest as in shrub-grown areas. Shrub habitat, like marsh, is important to the Illinois avifauna, both for its high population densities and for the variety of specialized species it supports. Fortunately, land use in Illinois will probably never attain a state of equilibrium that will eliminate shrub-grown areas completely, but the day may come when some acreage will have to be

managed specifically to create shrub habitat in order to maintain an interesting segment of our avifauna.

In little more than a century, orchard habitat in Illinois came into existence, expanded to an area of over 300,000 acres that supported nearly 2,000,000 breeding birds, and then decreased drastically. Today, partly because of the limited acreage, the bird population (about 110,000) in orchards of the state is almost negligible and will probably remain so in the coming decades.

Forest, the woody habitat with the most varied fauna but lowest population density, will probably continue to increase slightly in acreage in the coming years. This increase will help to increase the state population of birds and maintain the variety of species. Like other natural habitats, forest may ultimately be endangered by the swelling human population with its needs for lumber, food, superhighways, dwelling areas, and trading centers.

The elm diseases, which have left dead trees in forests throughout much of Illinois, have created a special habitat that may for a short time favor population increases among certain picids and other cavity-nesting birds.

Urban residential areas, which now boast a higher bird population density than any other habitat except edge, occupied an almost inconsequential acreage only 100 years ago. By 1909, urban area in the state was up to 350,000 acres and accounted for about 3,000,000 birds (6 per cent of the state population); by 1958, the area exceeded 800,000 acres, accounting for nearly 8,000,000 breeding birds (13 per cent of the state population), and was growing at an ever-increasing rate. The end of this growth is not in sight, and, because urban areas are claiming an increasingly important role in the development of the Illinois avifauna, this habitat deserves careful and intensive study. Most of the state population of introduced problem species (starling, house sparrow, and rock dove) is produced in residential habitat. To some extent, these introduced species are probably effecting limitations on native species in the urban residential avifauna, but, even if the exotic species were not present, the urban fauna would be restricted in variety. The house sparrow

population appears to have reached the saturation point, at least in old urban areas, but, because the urban residential habitat is expanding, the sparrow population will increase. The starling also should continue to increase in numbers; its population may not yet have reached the saturation point in any habitat.

To date, conscious efforts to control sparrow and starling populations by planned elimination of their nesting sites have been negligible. The "gingerbread" house and similar architectural patterns of past decades, because they offered a multiplicity of nesting and roosting sites, were probably especially favorable to the sparrow and starling. Few native species make use of human dwellings; therefore, building design offers an important and specific technique for the control of the three introduced problem species. The common practice by realtors of planting fast-growing softwood trees in new housing additions probably favors some native species of birds. The practice also favors the starling. Landscape architecture offers another effective avenue of control for problem species. From an economic standpoint it is, of course, not feasible to quickly supplant established housing and landscape features, but at present the acreage of residential habitat in Illinois is expanding greatly, and some effort should be made to at least study the possibilities of planned control of problem bird species by building and landscape design.

Residential habitat itself is changing in character. The newly developing large acreage of suburban housing will, for some years, have limited arboreal habitat for birds, and the house sparrow will probably dominate the early stages of suburban birdlife. The absence of large trees in new suburbs and the low-level dimensions of many suburban houses should discourage starlings to some extent in these areas. The bird-attracting potential of new housing and landscape designs remains to be determined. Because of the absence of large trees, grackles, flickers, crested flycatchers, and some of the other prominent species of older residential areas will be largely missing from the suburbs for some time. Developing small trees and shrubbery should favor some native species. The robin, which seems to have be-

come dependent on residential habitat, and the mourning dove should increase their populations.

Before 1980, there will probably be over 1,000,000 acres of urban residential habitat in the state, with a bird population numbering over 10,000,000 and including as many as 6,000,000 house sparrows and starlings in this habitat alone. Properly managed, this acreage could be made more pleasant for its human inhabitants and attractive to a variety of desirable native species of birds. Urban and suburban business districts, which are beginning to absorb a significant fraction of the state acreage, represent an almost total loss as habitat for native birds (except night-hawks), but they support large populations of the three introduced species.

Road and highway surfaces and rail-road trackage also represent lost habitat acreage for birds. We have estimated that about 600,000 acres of Illinois land were covered by road (surfaces only) in 1910, and over 1,100,000 in 1960. More acreage will go under concrete as highways are widened and work on four- to eight-lane interstate routes is expanded. As many as 1,500,00 acres may thus be utilized in the state by 1980. Along the margins of this highway system is a grassy roadside cover that in 1960 occupied nearly 400,000 acres along primary roads alone. This habitat—useful to a few native species of birds, notably meadowlarks—should increase in acreage in the coming decades, especially along interstate routes. This road-edge habitat warrants special study for its value to birds.

An unknown in relation to the expansion of these urban and highway areas is where the acres will come from; that is, what present habitats will be reduced to make room for the expansion? The probability is that most of the acreage for the expansion will come from open cultivated fields, particularly row crops, which would represent little loss to birds; in some areas, in the southern zone especially, some forest or shrub acreage may fall to the burgeoning cities and highways, and this would represent a definite loss.

The habitat changes discussed above had a profound effect on the Illinois avifauna, but it is difficult to understand some of the observed population changes,

and probably it is misleading to generalize about them. It is easy to see that the reduction in acreage of orchards, a habitat notably concentrated in the southern zone, could have reduced the orchard oriole population in this zone from about 400,000 birds in 1907–1909 to 100,000 in 1957–1958. On the other hand, it is difficult to understand why the blue jay population should have lost over half a million birds in the southern zone in a period when woody habitats were expanding. It is reasonable to assume that the introduction of the starling may have played some role in the decline of such cavity-nesting species as the red-headed woodpecker and flicker and that the expansion of woody habitats had a bearing on the increase in the indigo bunting. But what of the virtual elimination of the lark sparrow, which in 1907–1909 had a population in the southern zone of at least 300,000 birds? Here, for the most part, we can only point to the population changes; we cannot explain them. There is room for speculation and there are many factors to consider—climatic changes, habitat changes, competition, genetic vigor, and others—but all paths of speculation lead inevitably to more and more questions and the ultimate realization that each of these species needs special, detailed study. We should not forget, either, that the apparent population changes may represent transient conditions—normal fluctuations or temporary setbacks from which any or all of the species mentioned may come back in force.

Among the factors that complicate the interpretation of apparent population change in a given species is a lack of precise information on the relative importance of various habitats to that species. The census data revealed that few species of Illinois birds spend the day solely in only one or two habitats. Even some forest species spend time in open fields, figs. 31 and 32.

We have hypothesized that the high bird population of a few relatively stable natural habitats characteristic of primitive Illinois declined in the 19th and early 20th centuries as the natural cover gave way to the agricultural and other managed habitats that came with white settlement and that, although for most of these new Illinois habitats there was no real

avifauna, an agriculture-adapted avifauna was probably beginning to develop even as agriculture came to dominate the land.

When the Illinois bird population reached its low we cannot say; by 1907-1909, at a level of 61,000,000 birds, it may have been climbing. In the next 50 years, despite waning populations in a number of species, especially inhabitants of savanna-type areas, the total Illinois bird population remained about the same, principally because of a new introduction, the starling, and expanding populations in the relatively few species that comprised the avifauna for managed habitats. Be-

cause of these species the state population will probably increase in the coming decades. Even the redwing and horned lark populations have probably not yet reached saturation levels, and there may ultimately be increased use of croplands by a few other species.

Our prognostication that the number of birds in Illinois will increase in coming decades is based primarily on a consideration of changes in habitat and the response of a few species to these changes. In truth, we do not even begin to know all of the factors that will affect future populations of Illinois birds.

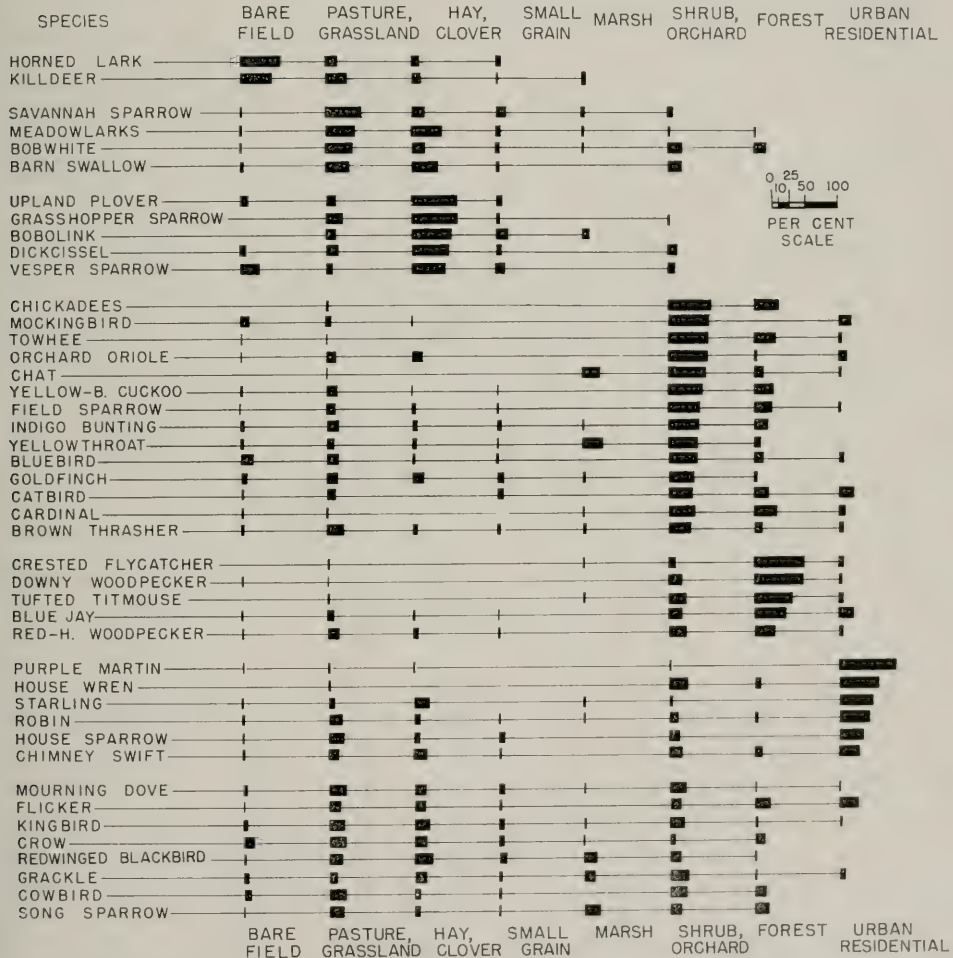


Fig. 31.—Habitat preferences of common species of Illinois birds in summer as indicated by the population density of each species in each habitat. Each black bar represents the relative density of a given species in a given habitat; the sum of the relative densities for each species is 100 per cent. Data are from all zones of the state and from all summer censuses.

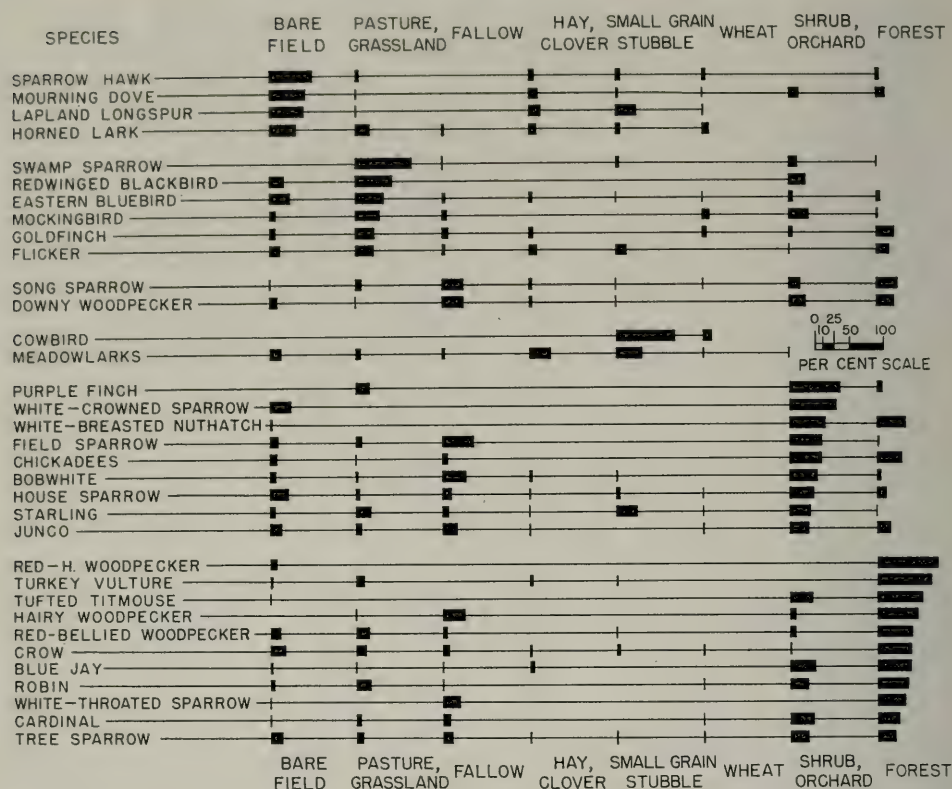


Fig. 32.—Habitat preferences of common species of Illinois birds in winter as indicated by the population density of each species in each habitat. Each black bar represents the relative density of a given species in a given habitat; the sum of the relative densities for each species is 100 per cent. Data are from all zones of the state and from all winter censuses.

To the multiplicity of factors involved in this extremely complicated subject, man has, in recent years, added to the complexity. In a sense, we have entered into a new era characterized by the widespread, regular application to the land of potent chemicals—insecticides, herbicides, and fertilizers. The acreage of Illinois cornland treated with chemicals for control of subterranean insects expanded from about 780,000 in 1958 (the last year of the second census period) to more than 3,500,000 acres in 1962 (Anon. 1963a:1). As we consider the increasing acreage of corn, soybeans, and other crops that are being treated with insecticides and herbicides, and the increasing acreage of roadside and other vegetation that is being killed with herbicides, we ask ourselves if we are not rapidly approaching the time when most of Illinois will be treated with toxicants of one sort or another.

We are only beginning to understand some of the effects of these chemicals on birds. Among the most important research needs in the state are detailed, carefully planned, and controlled studies of the effects of pesticides (insecticides and herbicides) on birds, their diets, their reproduction, their survival. We have suggested that, with the increased use of insecticides in orchards, population densities of certain species were reduced in this habitat. Mortality of birds as a result of applications of pesticides in a wide variety of habitats and geographic areas has been described and discussed by many authors (including DeWitt & George 1959; Scott, Willis, & Ellis 1959; Anon. 1962). There is ample evidence that this mortality results from both direct and indirect (through the food chain) intoxication (Bernard 1963:170, 188–90). Nesting success in a pesticide-treated area may be

greatly reduced because of loss of natural insect foods, or the intoxication of juvenile birds or adults (Hanson 1952:305-8; DeWitt & George 1960:8-9; and others). We are still short of data on the cumulative effects of sublethal doses of pesticides on individual birds and the long-term effects on whole populations. Particularly pertinent here is the evidence that certain widely used chlorinated hydrocarbons reduce reproductive capability in birds (DeWitt 1955:676; 1956:865-6; Anon. 1962:45-7).

What effect the widespread use of insecticides and herbicides in the various habitats will have on the future populations of Illinois birds remains to be seen. Because cultivated lands and urban residential areas are the habitats that are being most widely and regularly treated with pesticides, the very species of birds that have been increasing their populations in recent years may, in coming generations, be the species that decline.

Man and the Avifauna

Whatever the genetic or ecological characteristics of the species involved, it is abundantly clear that man, among the various forces that shape our fauna, is the dominant force of change. In his use of the land for food production, commercial enterprises, home building, and other purposes, he selects (albeit unwittingly) for some species of birds and perhaps inevitably against others.

In the history of a fauna, 50 years is an extremely brief period, and the coming years will probably accentuate the loss in avifaunal variety, even though the number of birds increases. The most unfortunate aspect of man's domination of the land is not that he changes the environment but that he changes it so widely so quickly. Species evolution requires time. Natural cataclysms may alter habitats quickly but not widely, or widely but not quickly. It is man who combines the two, who changes the face of the earth not in millennia but in decades.

For the most part, man has utilized the land without regard for the natural fauna. In North America, conscious management of bird populations, except those of a few game species, has been negligible. Yet for the past several decades man has been unwittingly manipulating bird populations on a wholesale scale. His domination has reached a critical and fearful level. Some obligation must go with this domination. Man has reached the stage when he must consider, in his manipulation of the environment, more than just his own primary needs. If there is to be a varied and interesting fauna for future generations to know, then management of the land must extend beyond human needs to the basic requirements of the fauna. Our lack of knowledge is the overriding deterrent to this type of management, but not the only one, and education of the public will have to follow the much-needed research.

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INDEX

In this index, page numbers referring to figures and tables are in *italic* type; page numbers for principal references are in **boldface** type. Of necessity, variation occurs in some of the terms indexed. For example, *cornfield* in the index may sometimes refer to *corn* in the text; *slate-colored junco* in the index may refer to *junco* in the text. *Shrubs* in one place may be synonymous with *shrub-grown area* in another.

For certain sections dealing with bird species and with habitats, inclusive pages for each are given in boldface type; for example, Robin, **485–6**, Pasture, **408–12**. Within the inclusive pages for any of these items, no text references to subdivisions of the items are indexed; for example, the acreage of pasture and the bird populations in pasture as given in the text on page 409 are not indexed; however, the acreages of pasture shown in the graph on page 388 and mentioned on pages 440 and 457 are indexed under *Pasture*, as are the bird populations in pasture mentioned on pages 440, 441, and 457; *dickcissel* as mentioned on page 409 is indexed under the entry *Dickcissel* as a species in pasture.

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